

Critical Review of Mobile Source Inventory Data in EPA 2016v1 and 2016v2 Modeling Platforms

Virginia Department of Environmental Quality

December 13, 2021

Emission and MOVES Versions (in Chronological Order)

- 2015 -- 2016: **2014NEI** in development
- 2018 -- 2019: **non-NEI** 2016 platform began (beta version)
- 2018 August: MOVES2014b released (a minor update to MOVES2014a)
- 2018 -- 2019: **2017NEI** in development
- 2020: **2016v1 continued, 2016v2 in development**
- 2020 November: MOVES3 released (a major update to MOVES2014b)
- 2021 March: MOVES3.0.1 (a patch to MOVES3)
- 2021 September: MOVES3.0.2 (another patch)
- 2021 -- 2022: **2020NEI** in development

Major difference between 2016v1 and 2016v2 is MOVES version (from MOVES2014b to MOVES3)

SMOKE-MOVES

- **SMOKE-MOVES, not MOVES, is the tool used by EPA to process onroad mobile source emissions for National Emission Inventory (NEI) and photochemical modeling for policy making**
- **Resolution for SMOKE-MOVES is representative county **spatially** and two (ozone season and non-ozone season) fuel months **temporally****
- **SMOKE-MOVES is a complicated modeling framework consisting of a suite of pre-processing (for MOVES), MOVES, post-processing (for SMOKE), and SMOKE**
- **Extensive and excessive computation is involved in the process**
- **Currently only EPA's contractors know how to run SMOKE-MOVES correctly**
- **No states have ever done SMOKE-MOVES**
- **Modeling inputs and outputs are all generated by EPA's contractors**
- **Available data posted by EPA represents only SMOKE portion of SMOKE-MOVES**
- **MOVES portion of SMOKE-MOVES is unknown (a black box)**
- **Massive amount of data have been generated but left unanalyzed over the years**
- **Control measures or strategies involving mobile sources by RPO/MJO therefore resort to "across-the-board" cut**

Why Consistency Matters

- **Inconsistencies are the result of ambiguous or insufficient guidelines for data gathering and not because of better local data collected by states**
 - **Vehicle splits: 31/32, 52/53, 61/62 (MOVES design issue)**
 - **Extended idling (changing methodologies over past 5 years)**
 - **Speed profiles and VMT temporal profiles (few sources for suitable data prior to 2014NEI)**
- **Inconsistent emission inventory results propagate into air quality modeling, often amplifying questionable data**
- **Contribution-to-monitor type of air quality modeling that includes inconsistencies unfairly favors some states while targeting other states**
- **Inconsistency must be corrected by either implementing the same methodologies across the board or revising MOVES internal design**

Clear unambiguous guidelines will help alleviate the problems

Representative County Approach

In SMOKE-MOVES, the role which **age distribution plays is not entirely clear (it's one of the factors used in representative county grouping)**

Grouping Criteria:

Fleet age distribution

Fuel properties

Control programs

Others (Extended idling)

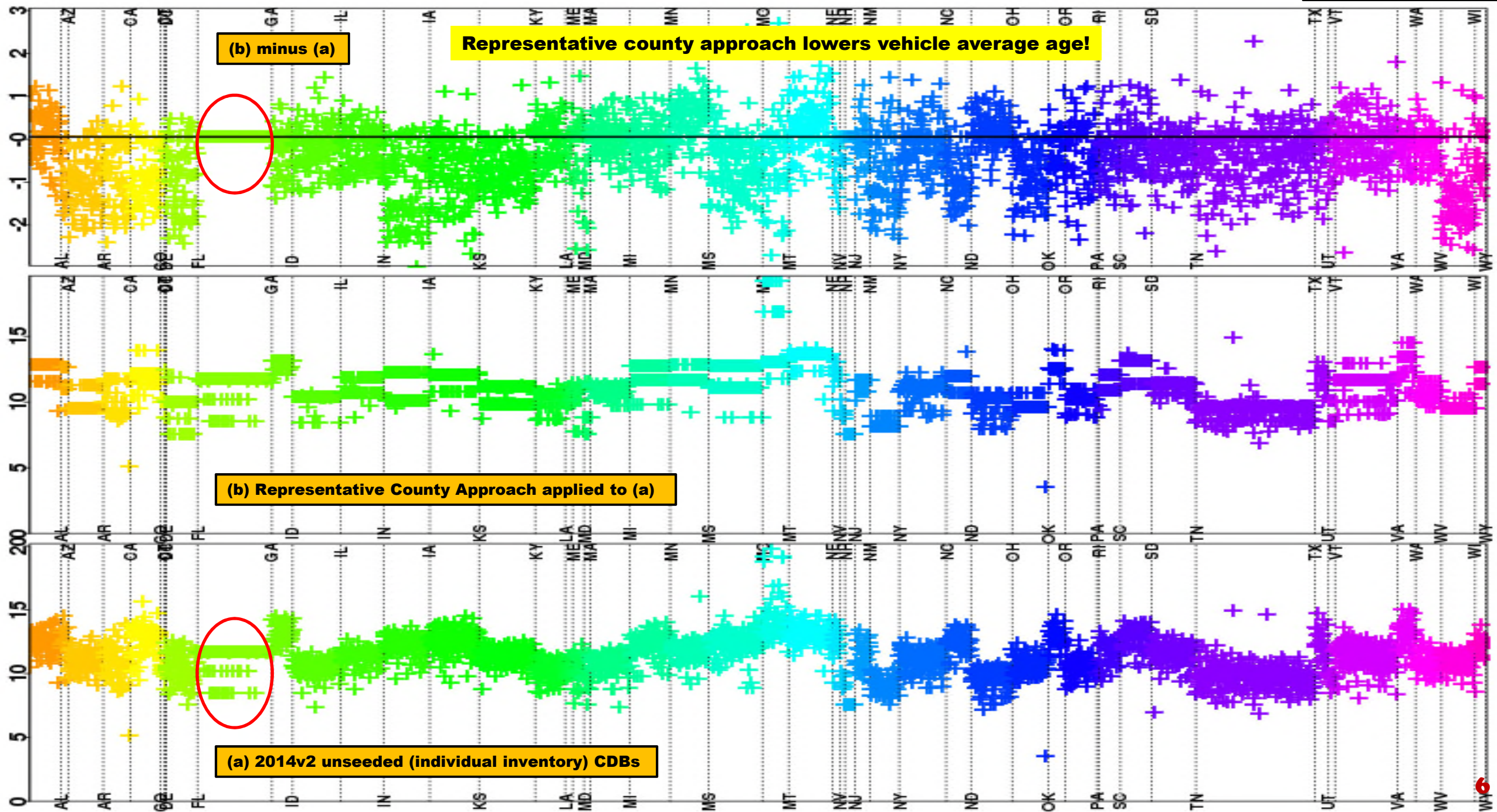
In inventory mode, age distribution is one of the most important parameters affecting onroad emissions. For SMOKE-MOVES, the impact of age distribution is hidden or embedded in emission factor (lookup) tables

Prior to 2014 NEI, the representative county approach had used data properties of the county with the highest VMT to represent a group of inventory counties (“old” practice)

Starting from 2014 NEI, EPA has revised the practice and used “population-weighted” age distributions (“new” practice) to represent a group of counties. No other change was made to representative county approach

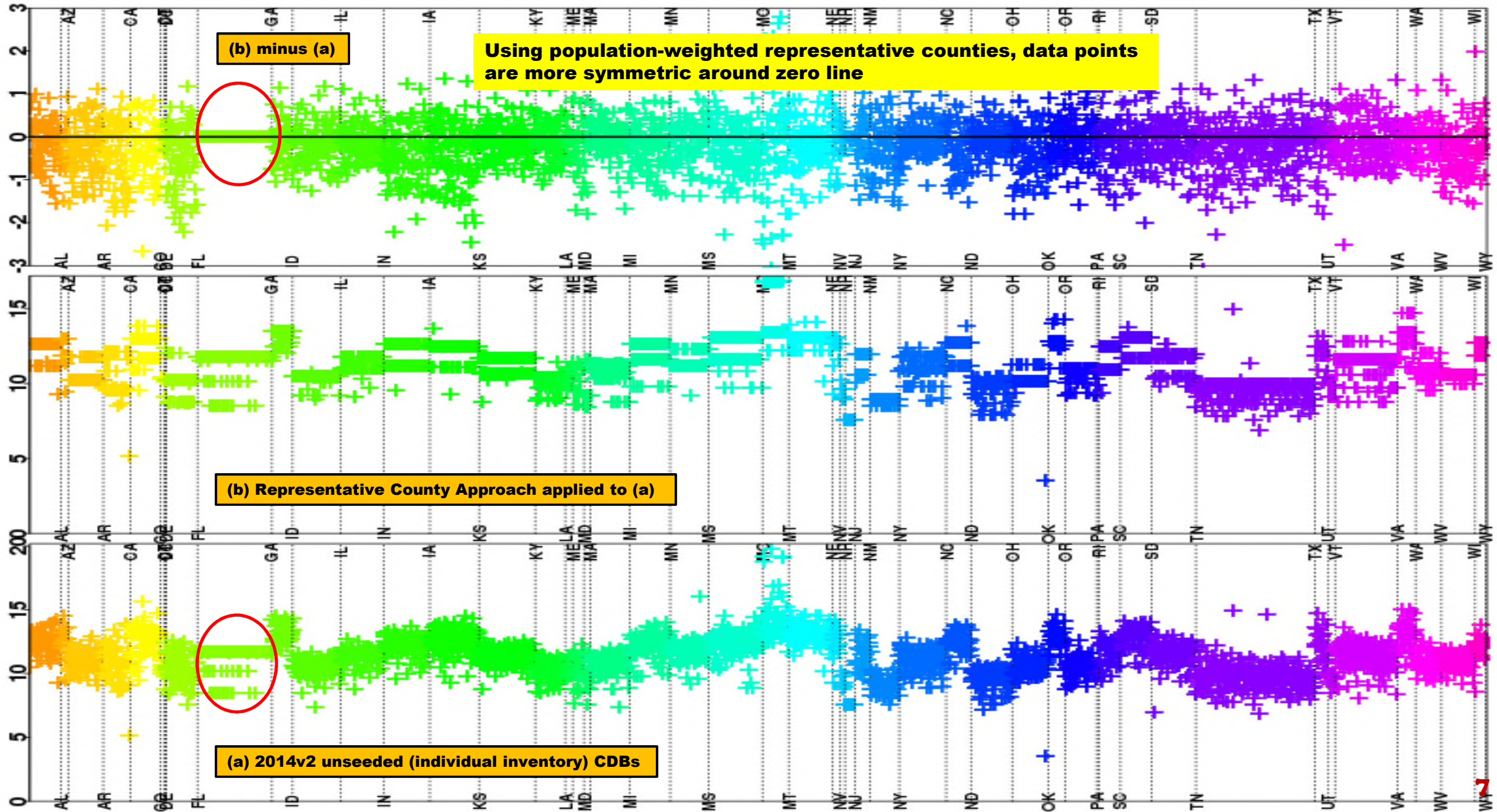
Effect of Representative County on Vehicle Average Age (21)

2014, old practice

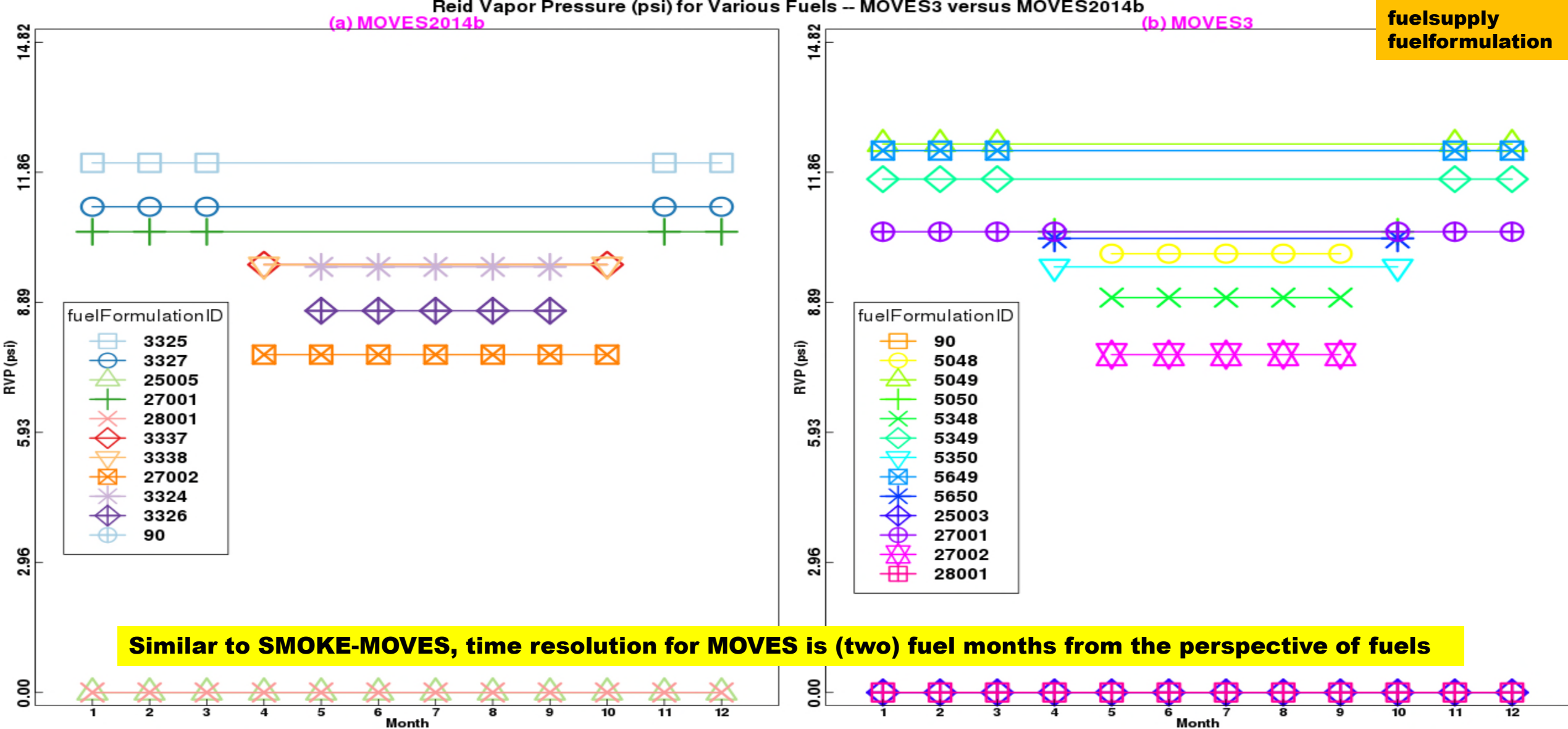


Effect of Representative County on Vehicle Average Age (21)

2014, new practice

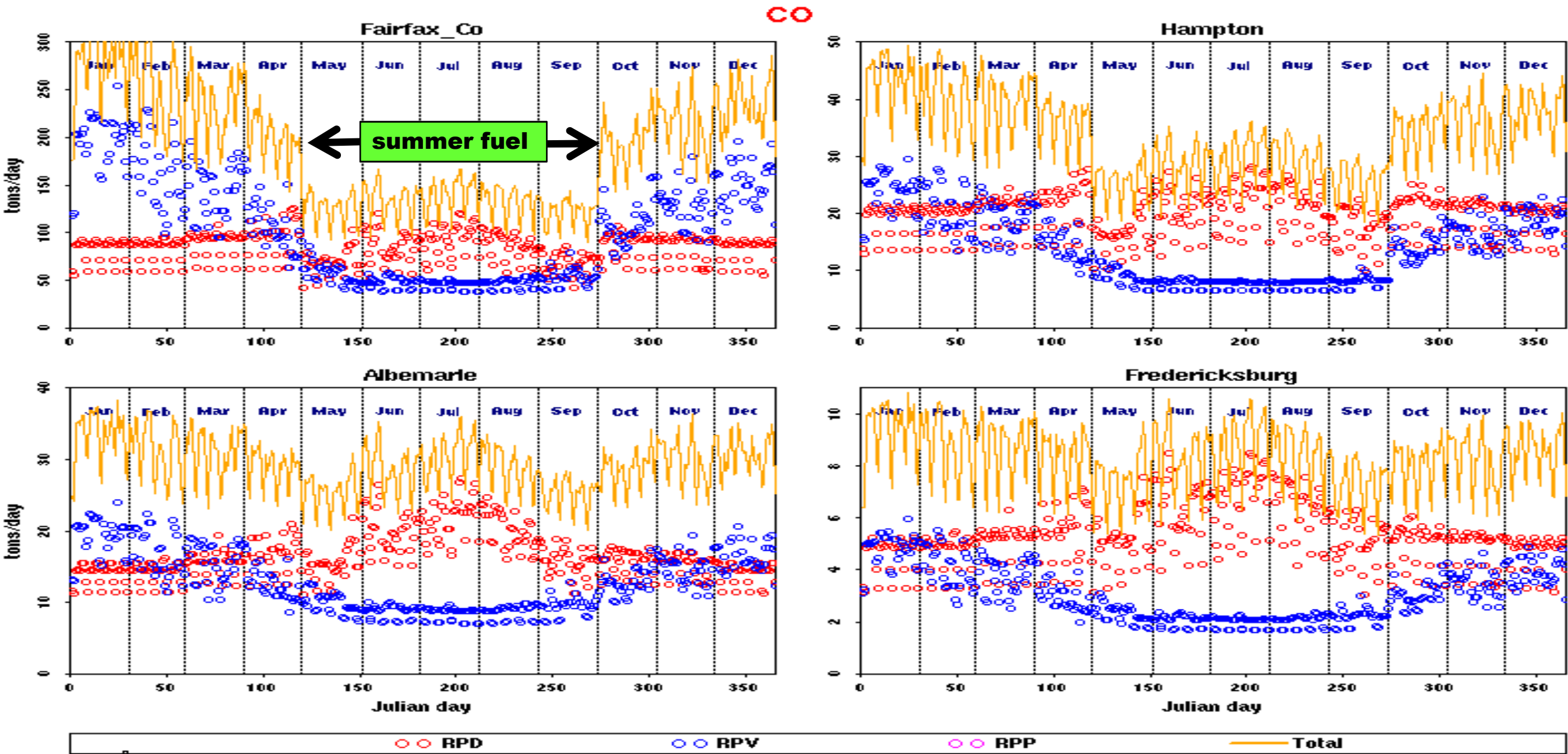


Reid Vapor Pressure (psi) for Various Fuels -- MOVES3 versus MOVES2014b



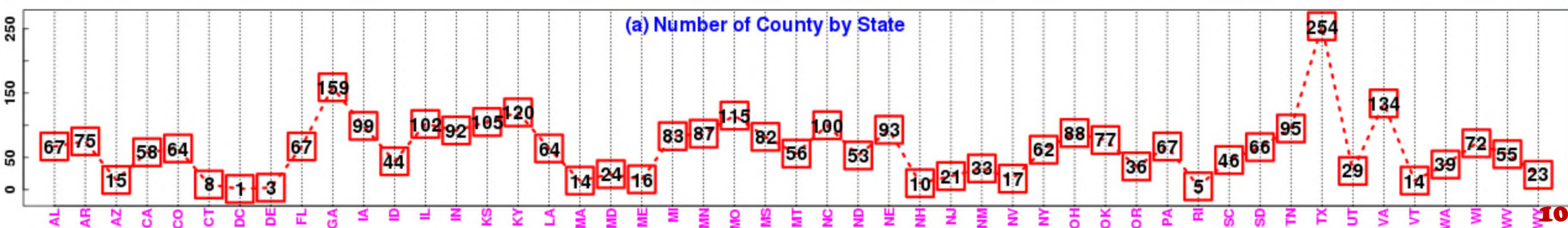
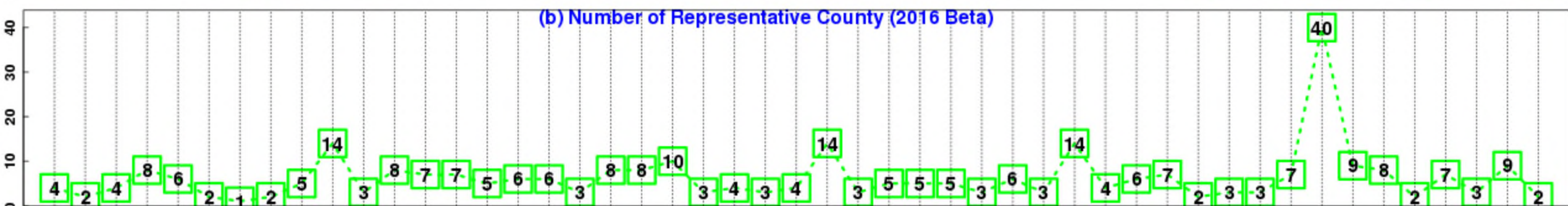
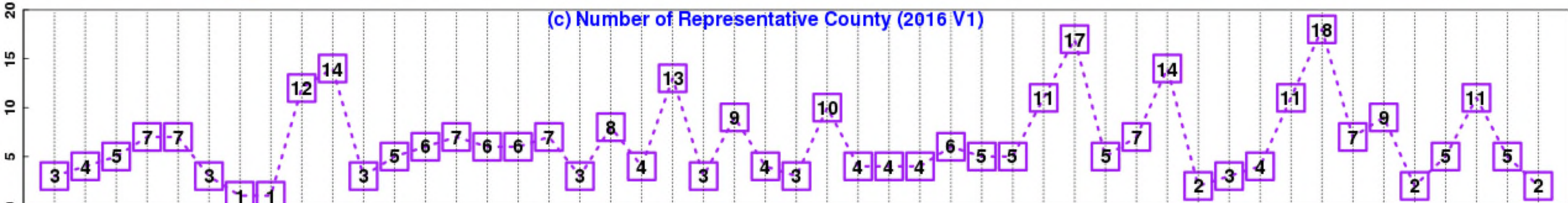
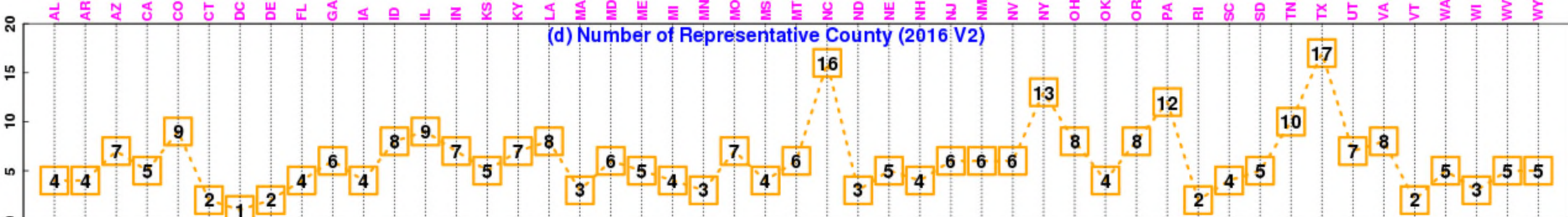
- This figure was made by combining data from fuelsupply and fuelformulation tables. It is for year 2016 and regionID 100000000 only;
- RVP for non-gasoline fuels (diesel, CNG, electricity) is zero;
- Gasoline/ethanol fuels generally are grouped into summer fuels and winter fuels (plus or minus shoulder months);
- RVP for winter fuels > RVP for summer fuels

VA 2011 Daily Temporal Profiles for Vehicular CO Emissions for Four Selected Counties



This plot was
made in July 2013

- Daily profiles by county show diurnal variations. RPP sector (VOCs only) does not contribute to CO;
- Discontinuity due to two fuel months starts to diminish as county emissions get smaller (Fairfax -> Hampton -> Albemarle -> Fredericksburg).



PA Passenger Truck (31) – 2016v2 versus 2023

$$\sum \text{fraction}_i = 1 \text{ (i=0 to 30)}$$

- 42003:ALLEGHENY
- 42007:BEAVER
- 42019:BUTLER
- 42039:CRAWFORD
- 42049:ERIE
- 42051:FAYETTE
- 42055:FRANKLIN
- 42057:FULTON
- 42071:LANCASTER
- 42089:MONROE
- 42091:MONTGOMERY
- 42101:PHILADELPHIA

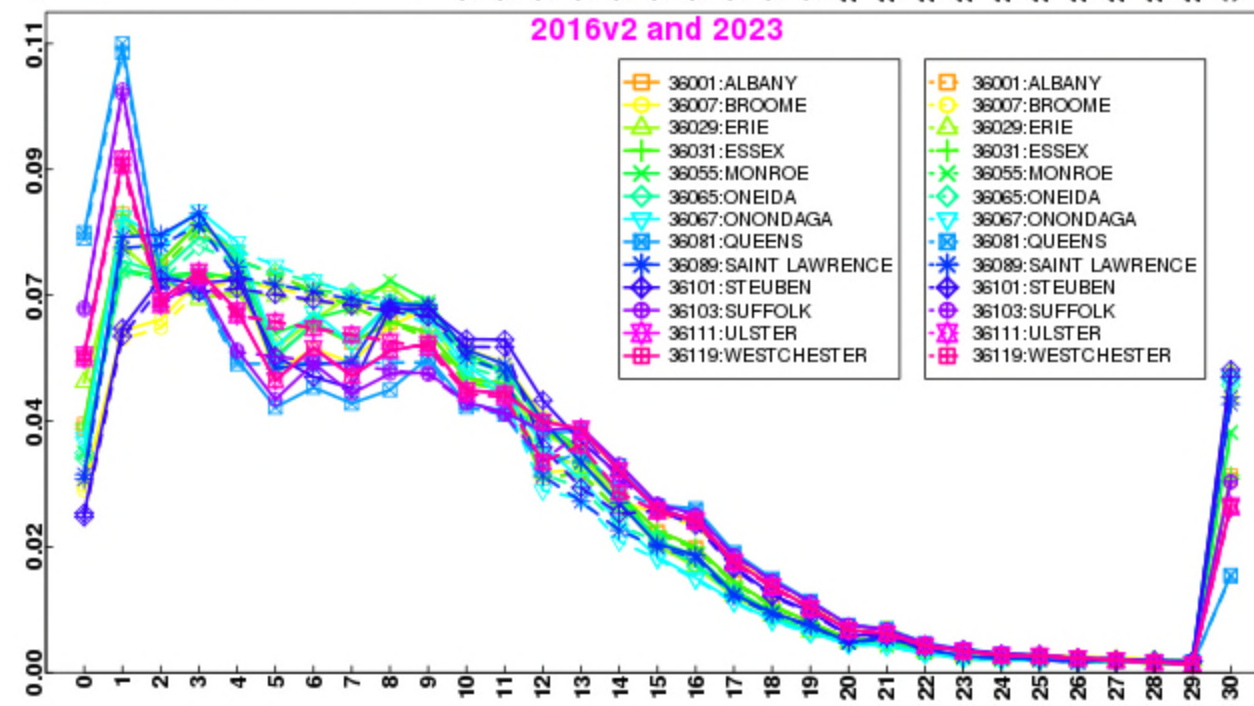
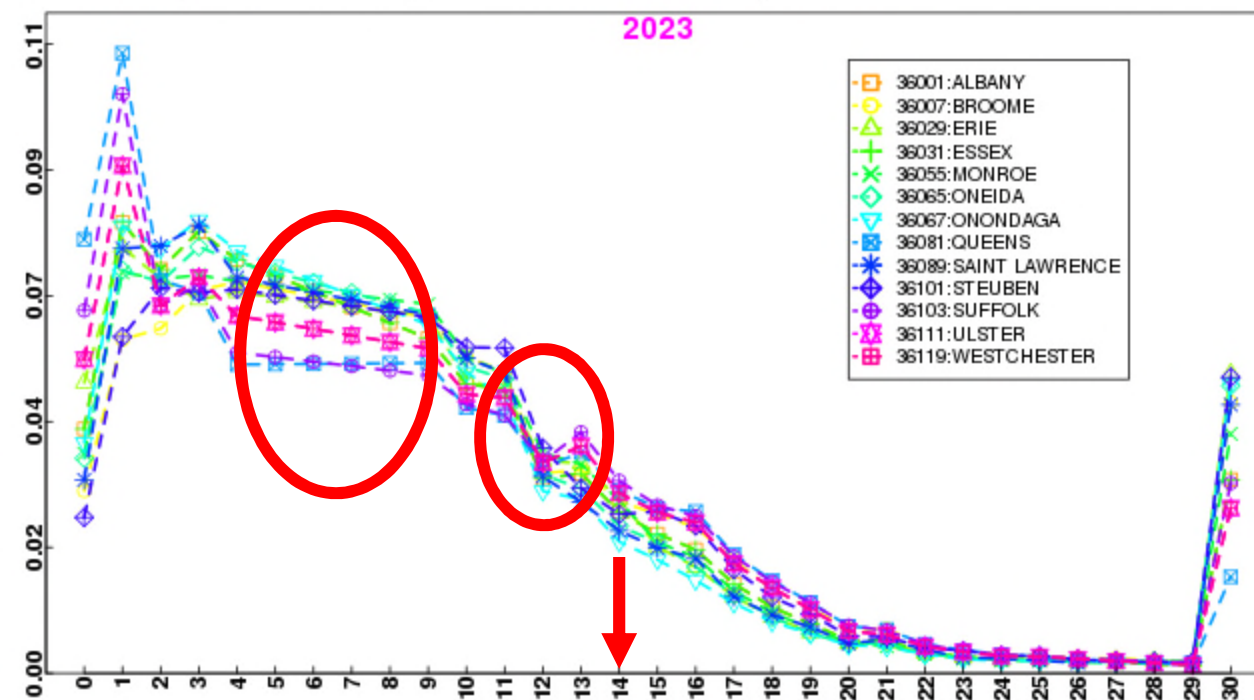
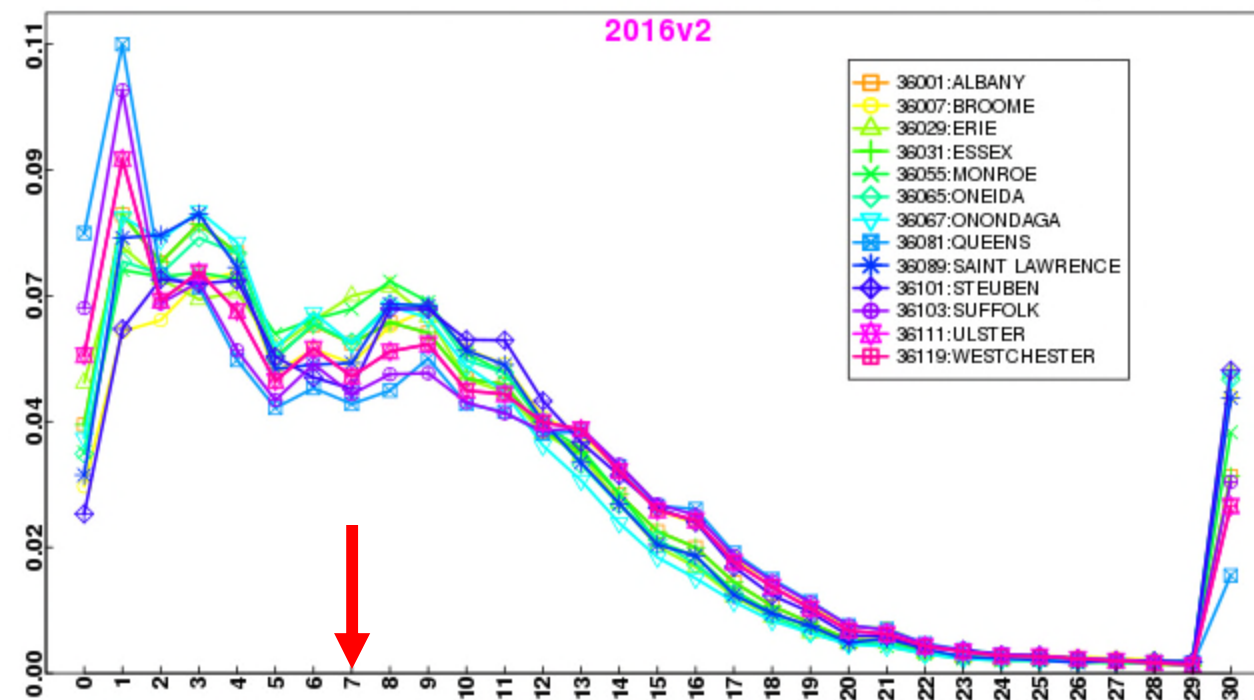
- 42003:ALLEGHENY
- 42007:BEAVER
- 42019:BUTLER
- 42039:CRAWFORD
- 42049:ERIE
- 42051:FAYETTE
- 42055:FRANKLIN
- 42057:FULTON
- 42071:LANCASTER
- 42089:MONROE
- 42091:MONTGOMERY
- 42101:PHILADELPHIA

2016v2 (solid lines) and 2023 (dash lines) age distributions have different meaning

-- 2016v2 may have been states-supplied or IHS data, but 2023 data is projected;
-- Age 0 means 2016 or 2023 vehicle model year

2009 recession wrt 2016

2009 cars will be 14 years old in 2023

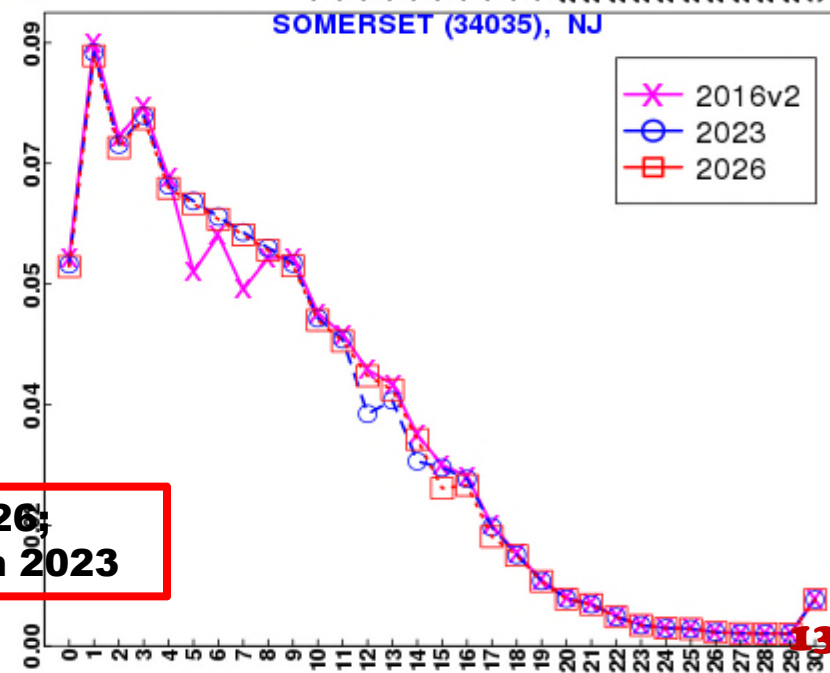
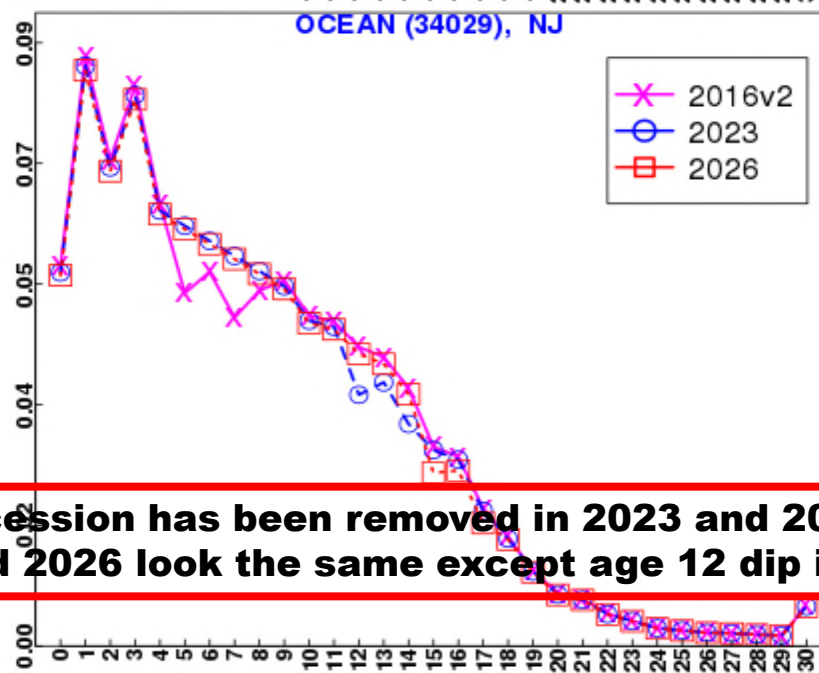
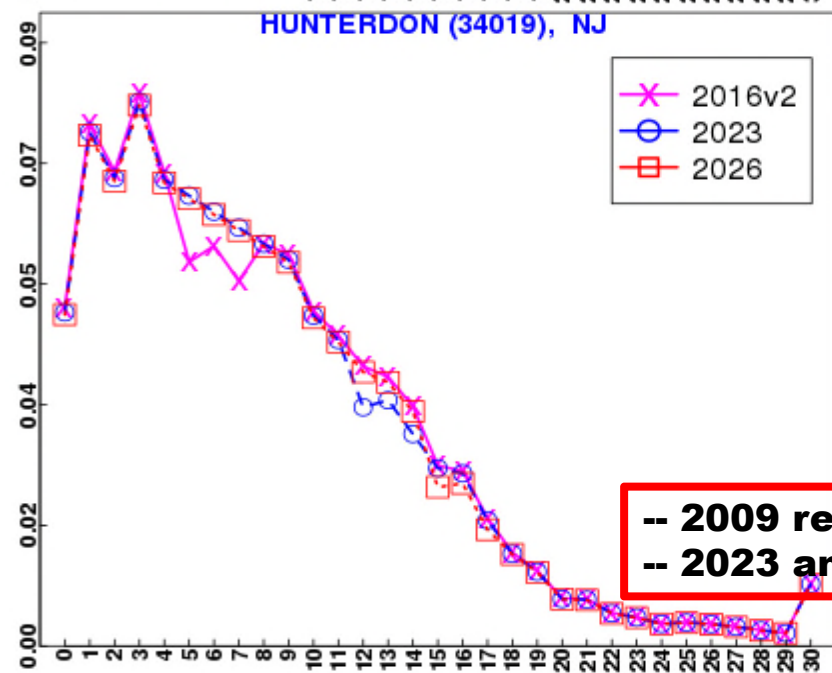
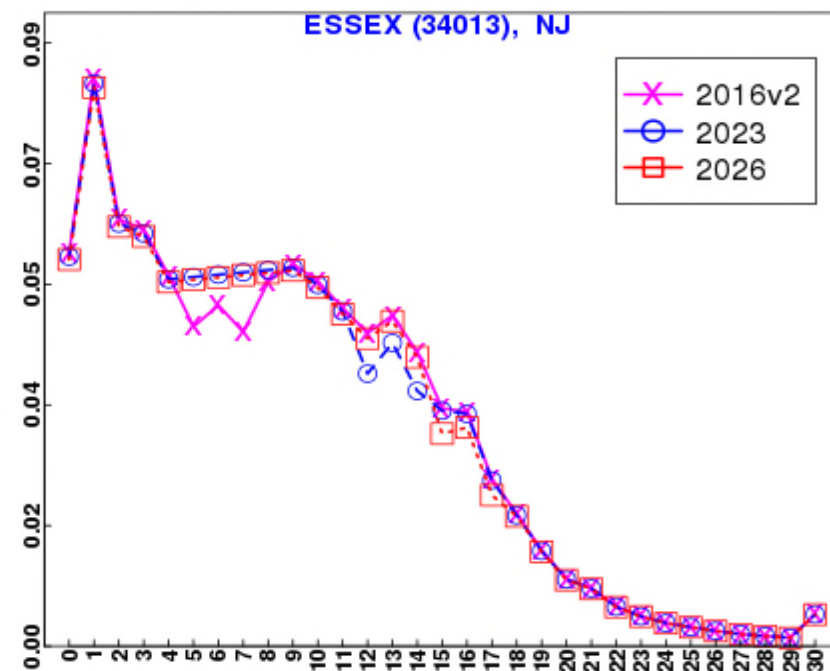
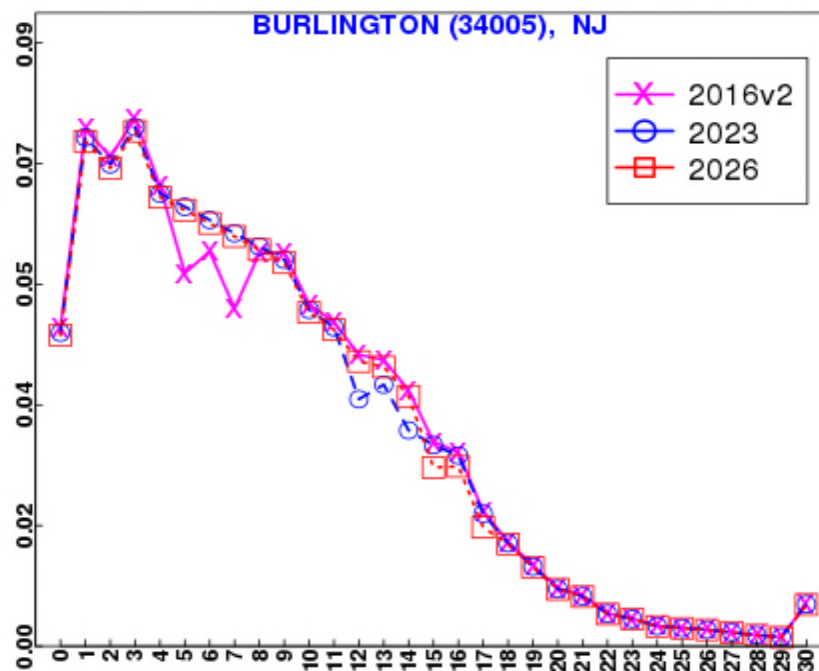
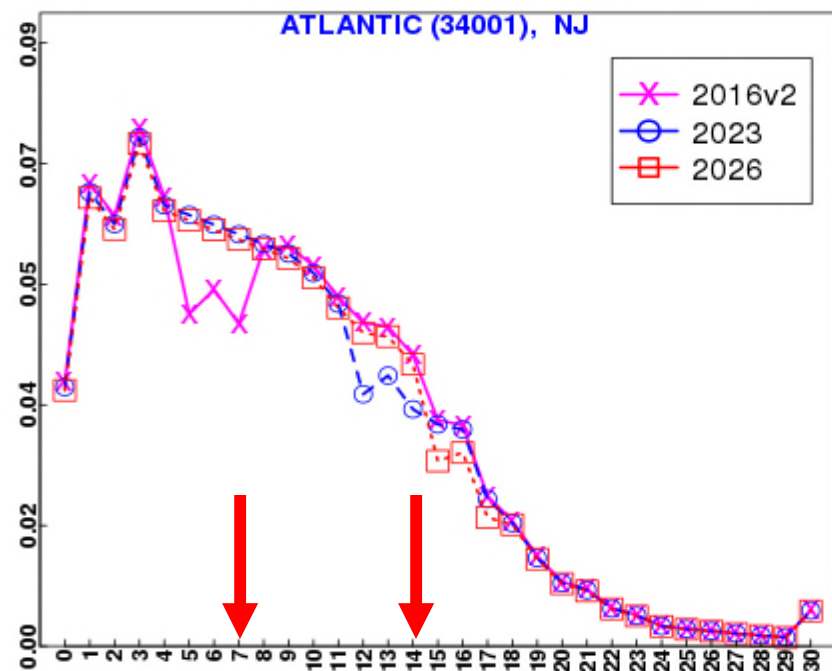


**NY Passenger Car (21) –
2016v2 (upper left) versus 2023 (upper right)**

**Removing the recession in 2023 is obvious,
but there is a dip in age 12 bin**

NJ Passenger Car (21) in 2016v2, 2023, and 2026

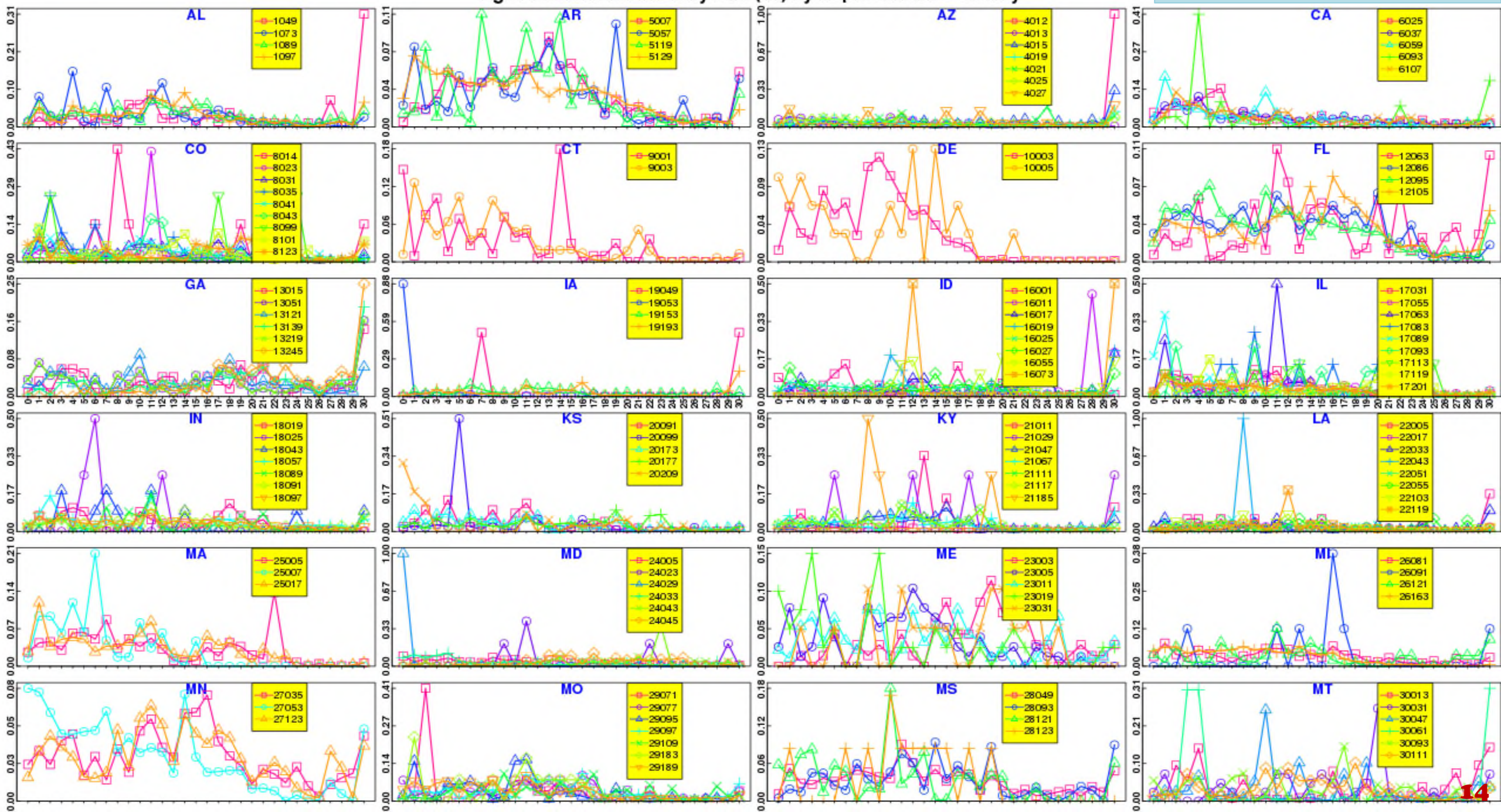
2016v2, 2023 and 2026 Age Fractions for Passenger Truck (21) by Representative County in NJ



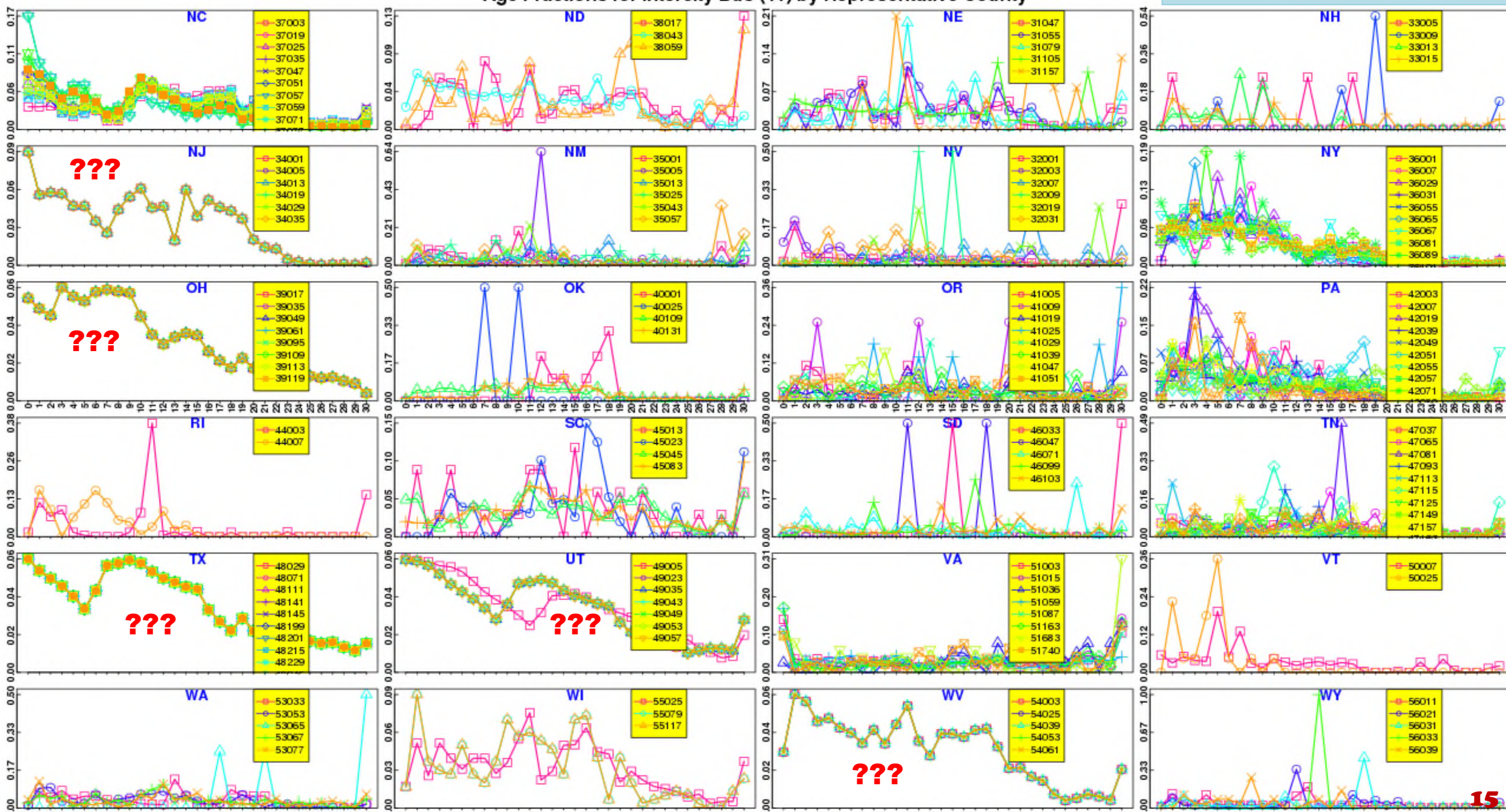
-- 2009 recession has been removed in 2023 and 2026
-- 2023 and 2026 look the same except age 12 dip in 2023

Age Fractions for Intercity Bus (41) by Representative County

2026, 41 fraction, CONUS1

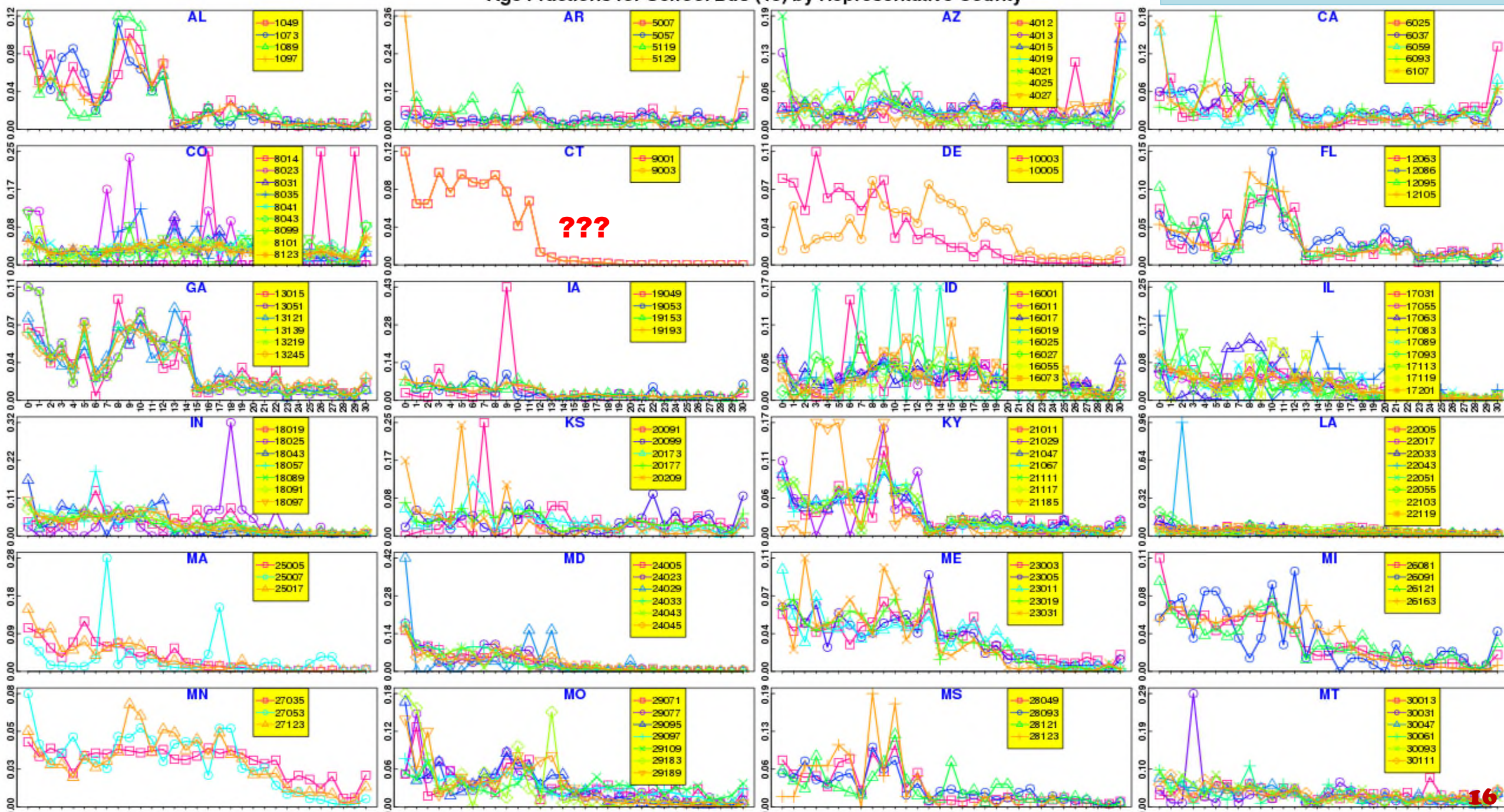


Age Fractions for Intercity Bus (41) by Representative County



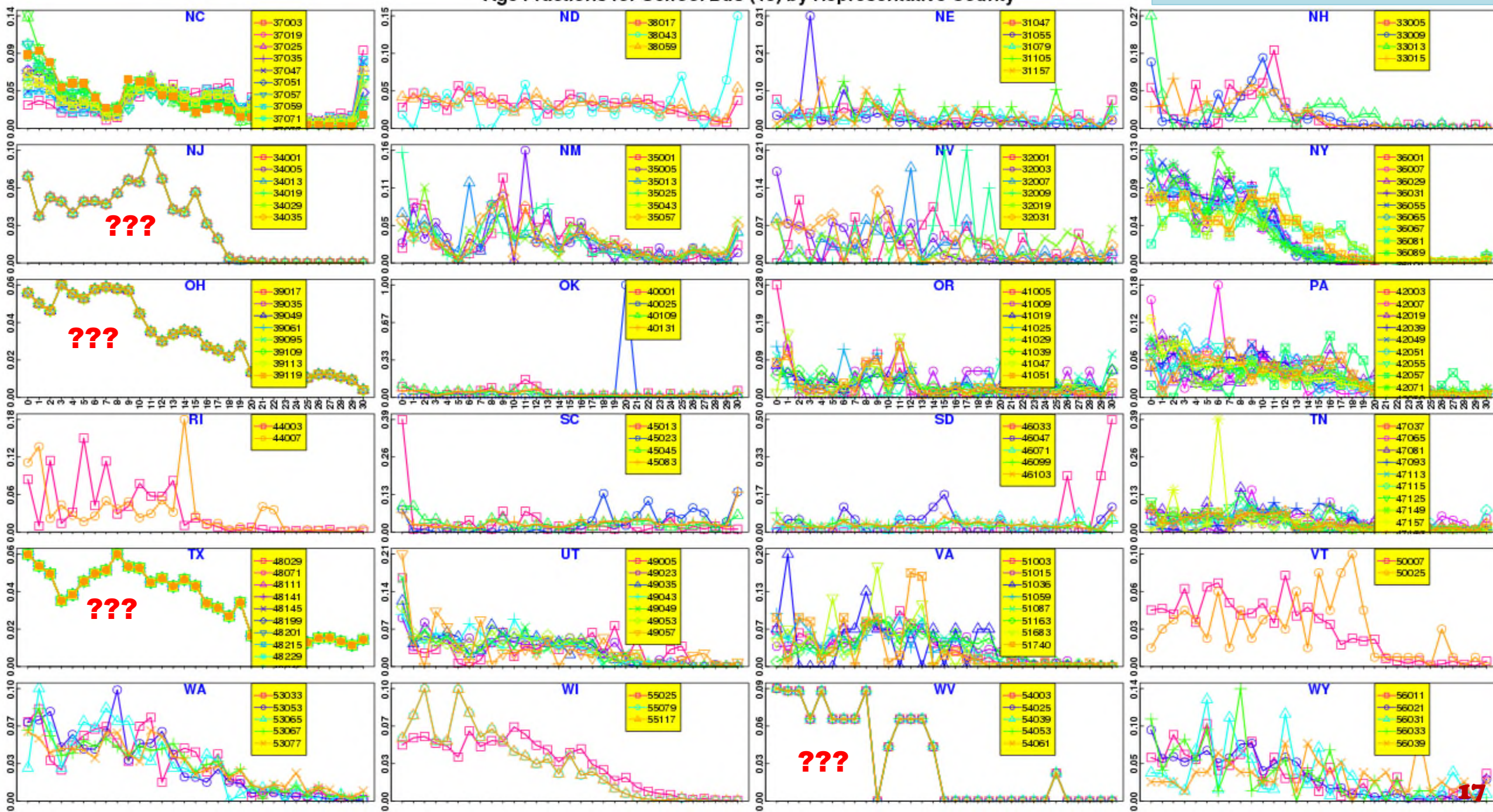
Age Fractions for School Bus (43) by Representative County

2026, 43 fraction, CONUS1

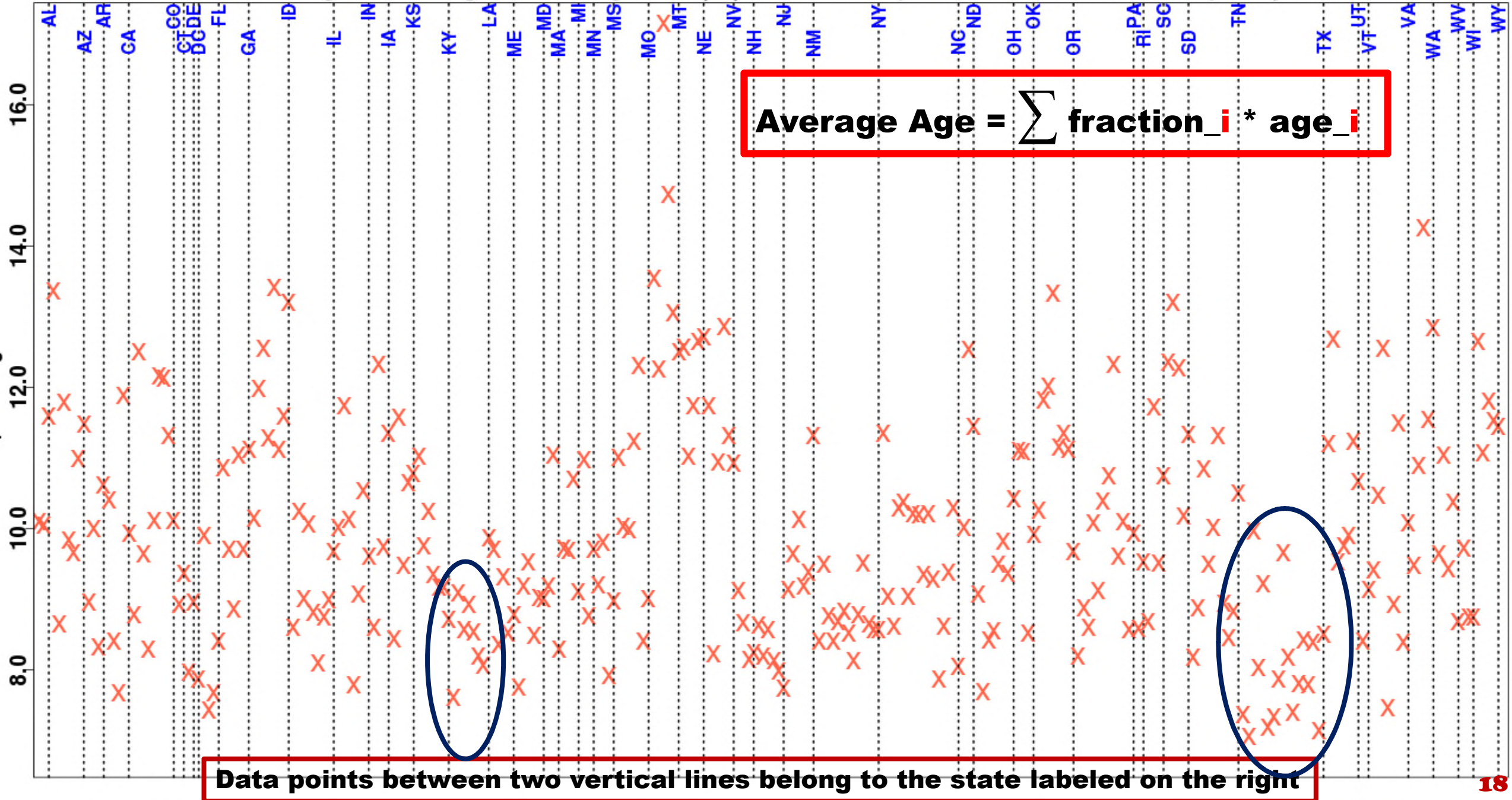


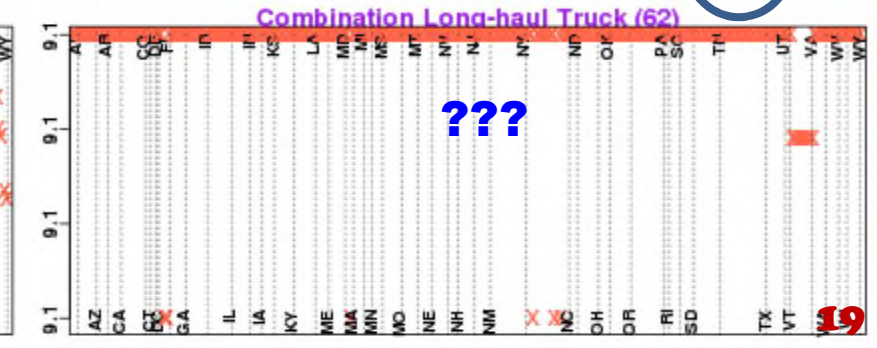
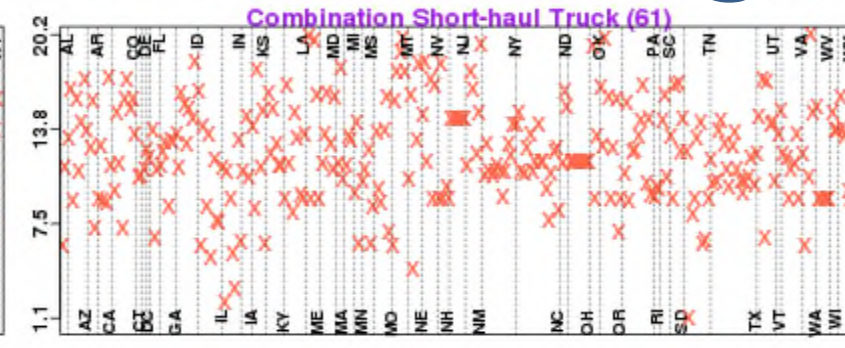
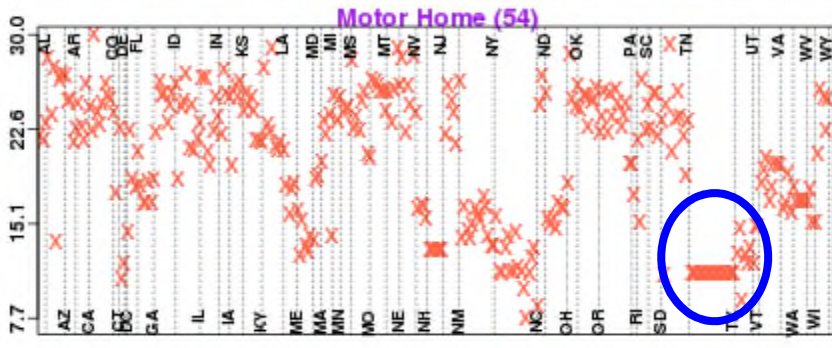
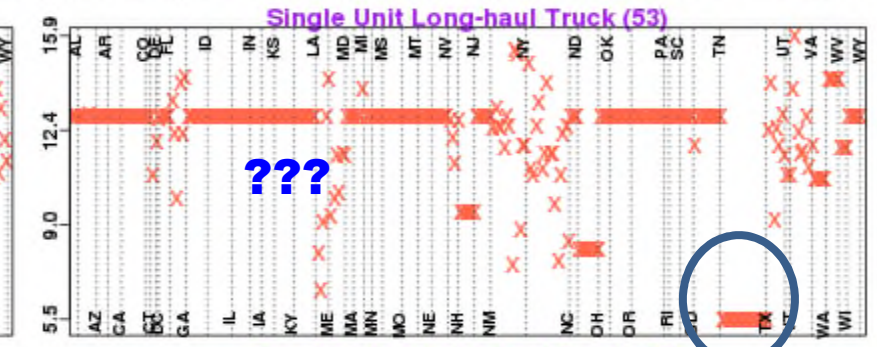
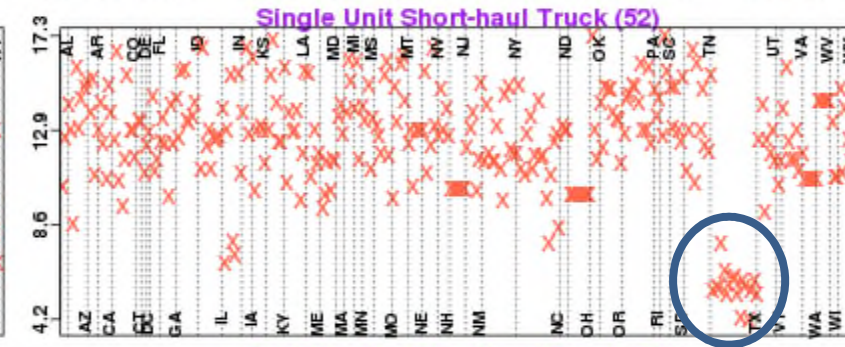
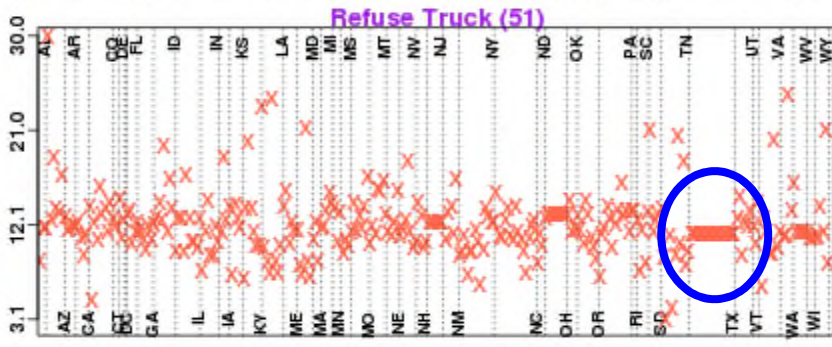
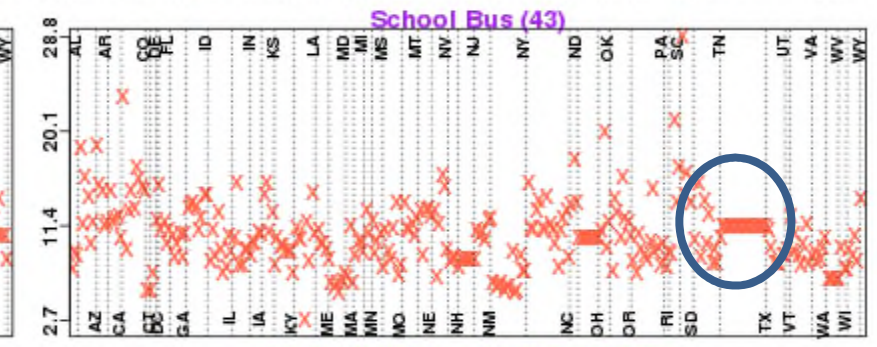
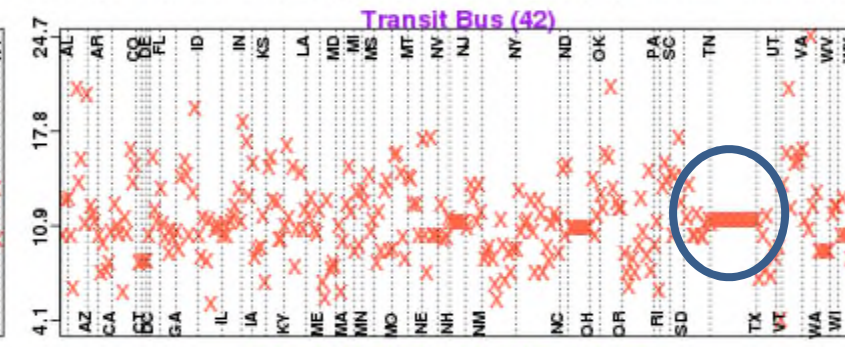
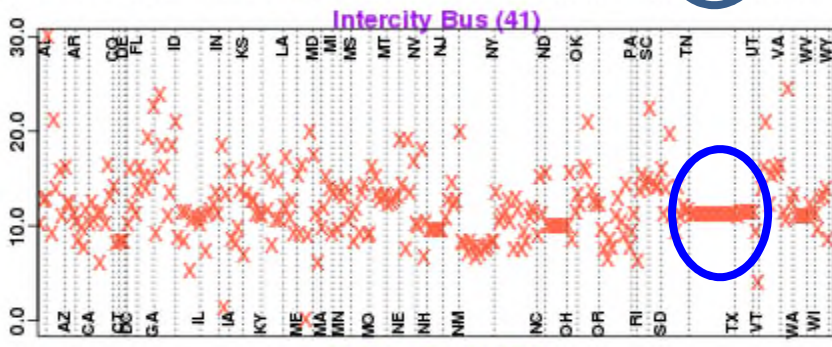
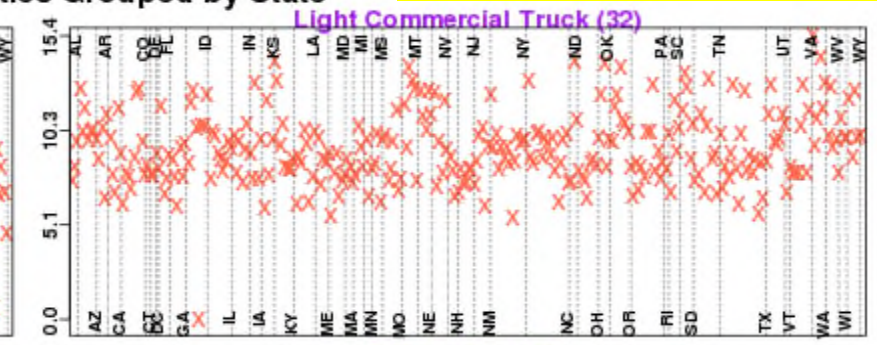
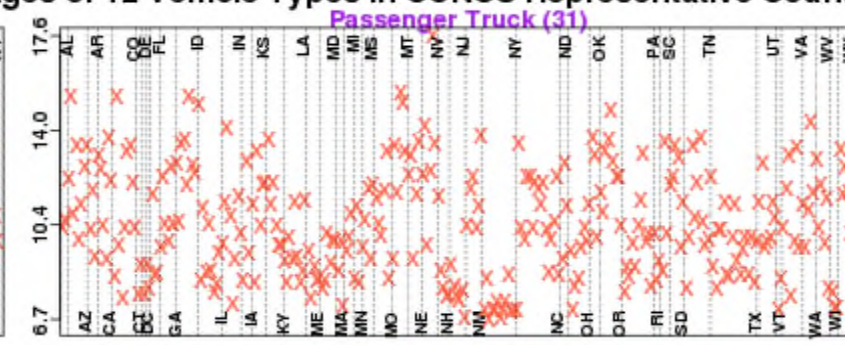
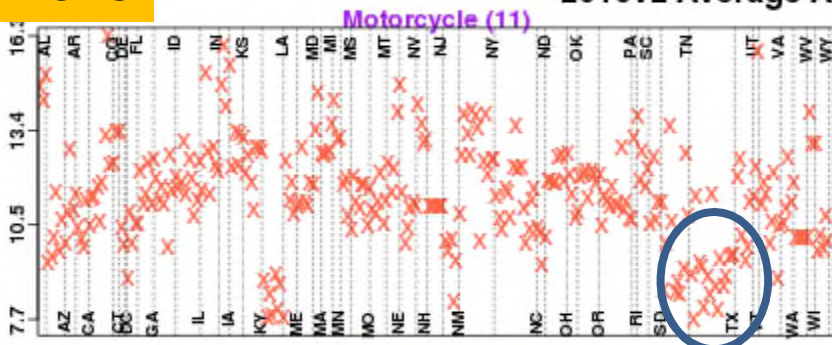
Age Fractions for School Bus (43) by Representative County

2026, 43 fraction, CONUS2

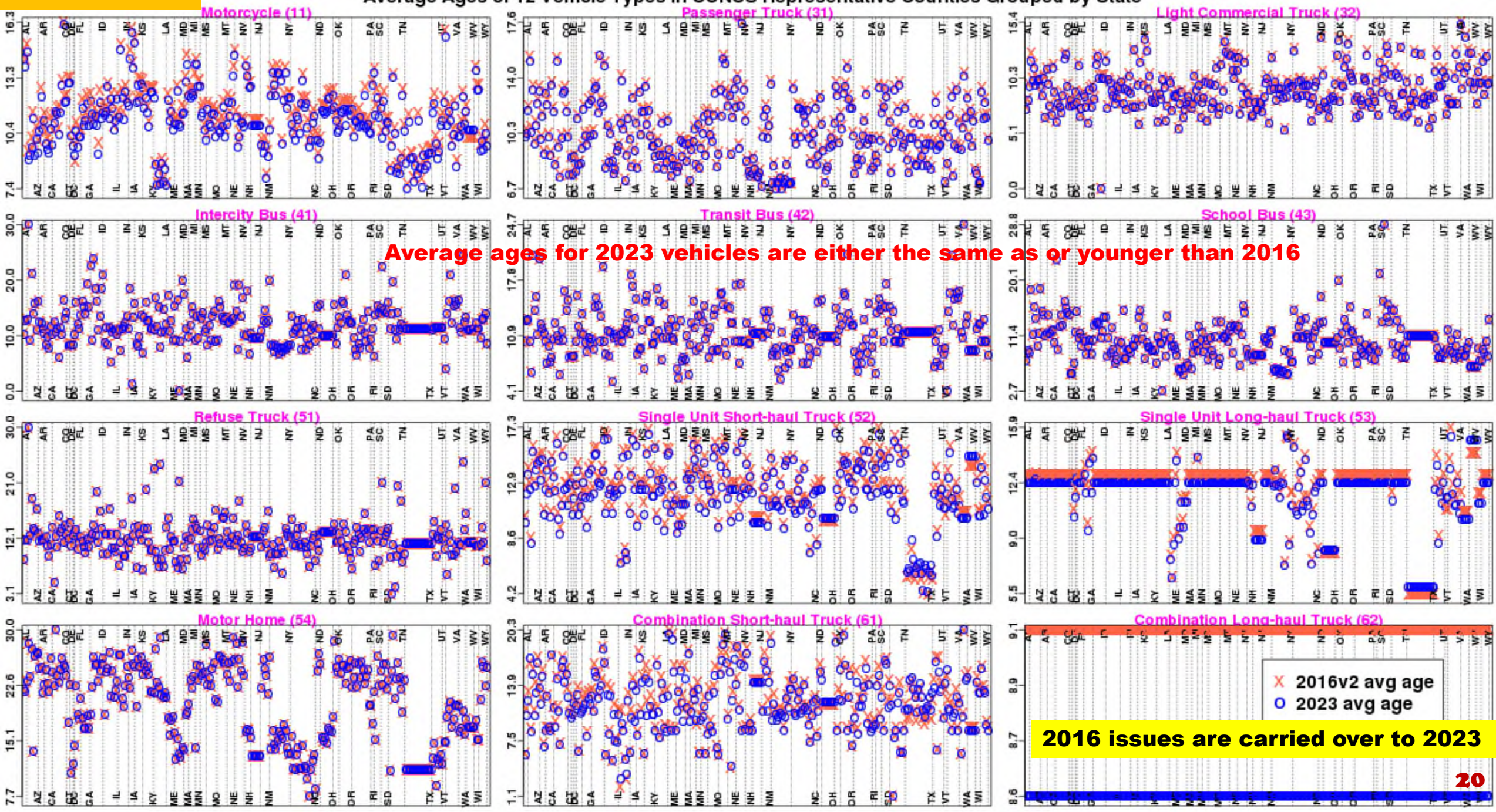


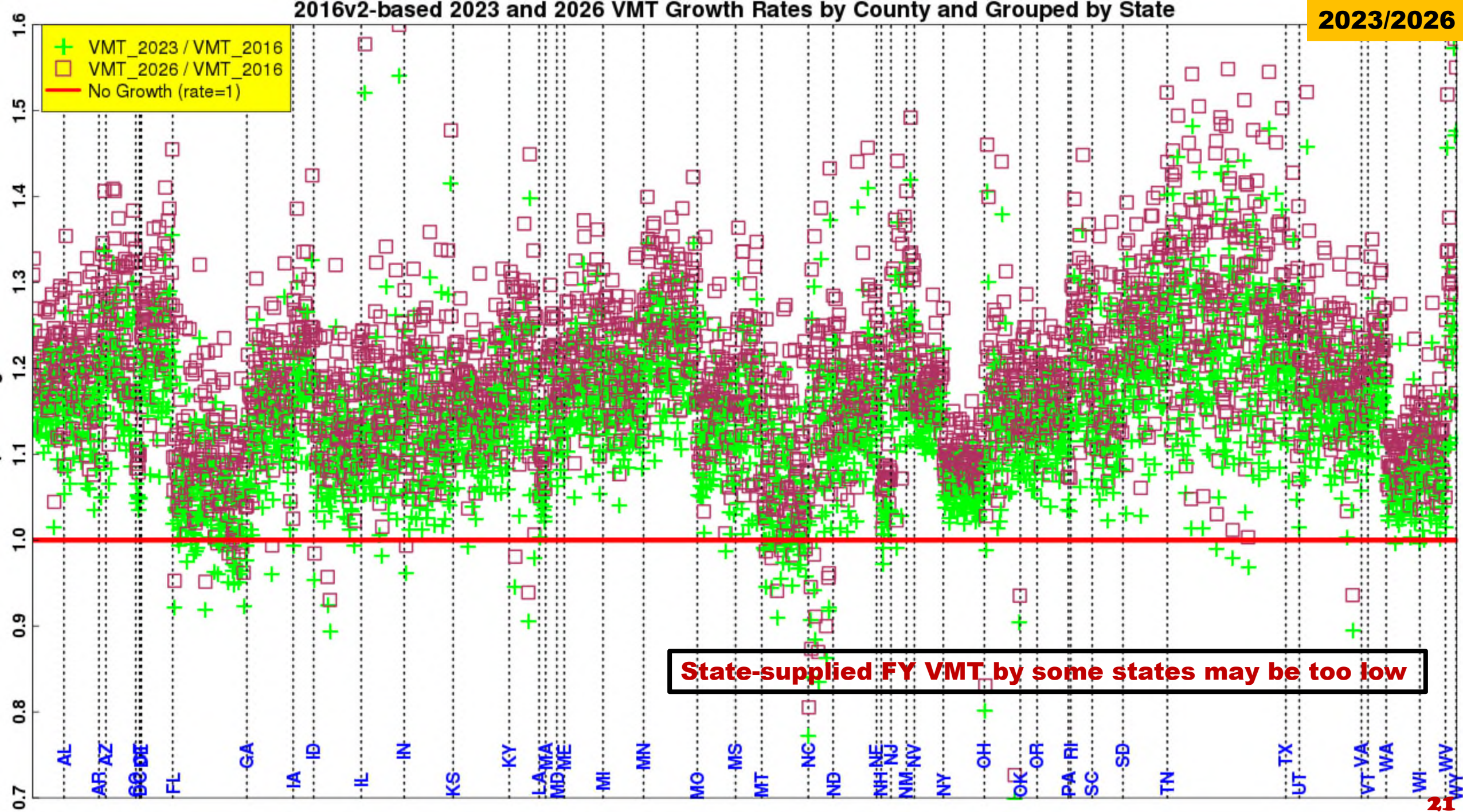
2016v2 Average Vehicle Age of Passenger Car (21) in CONUS Representative Counties Grouped by State

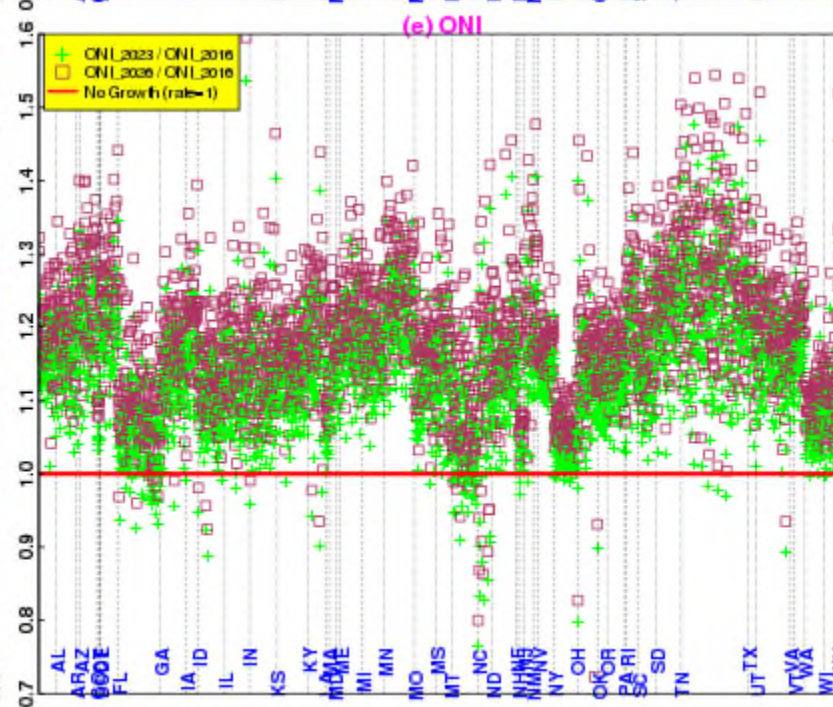
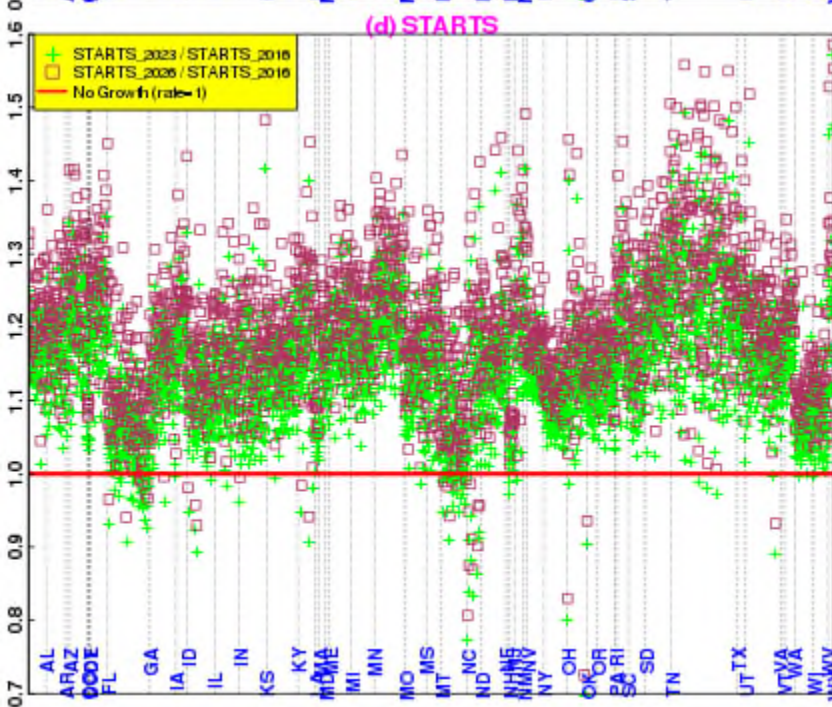
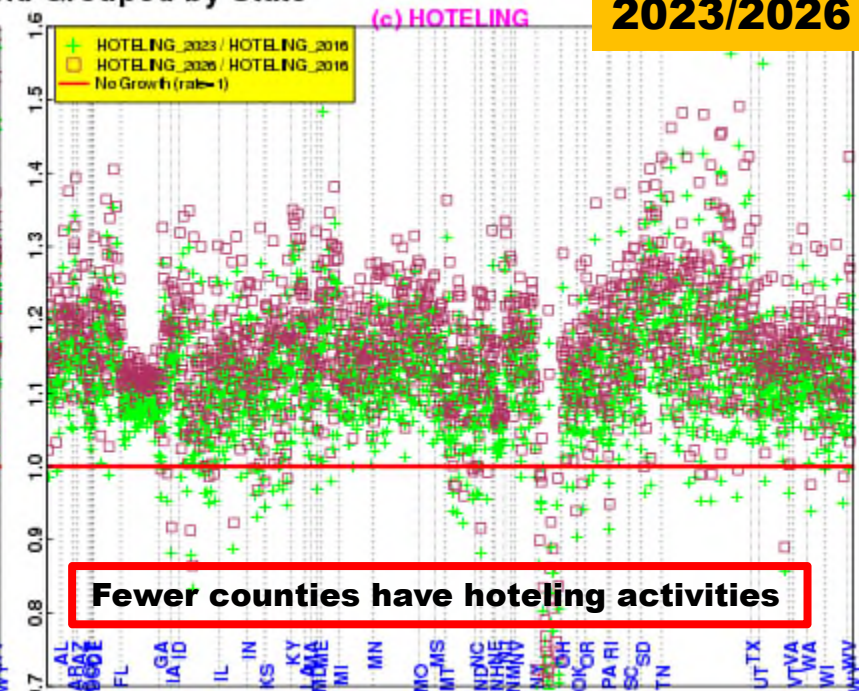
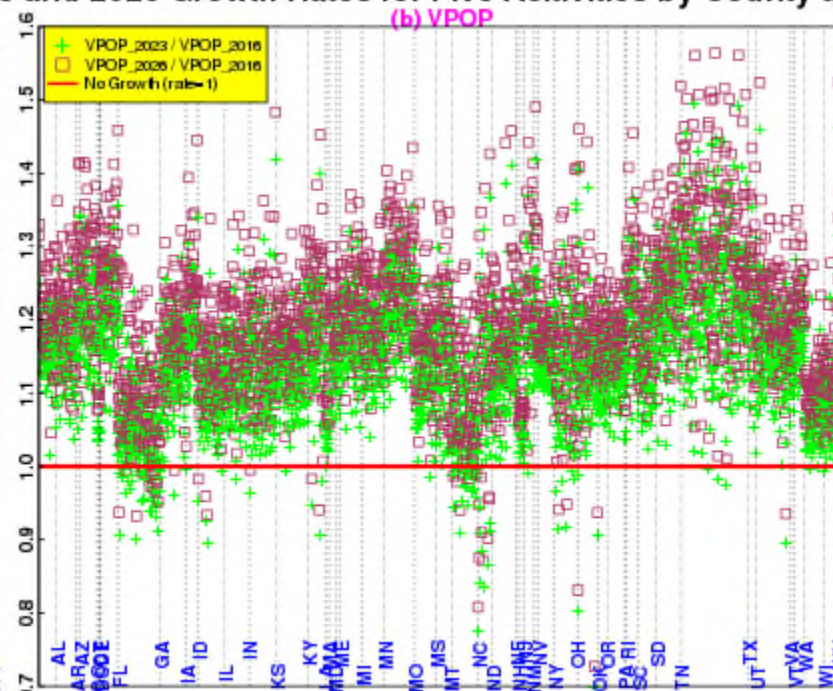
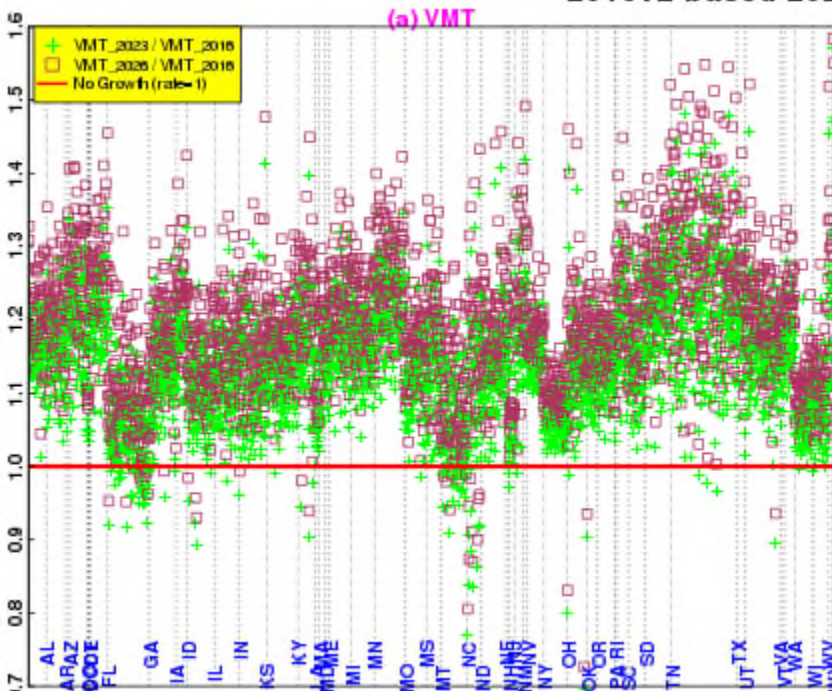




Average Ages of 12 Vehicle Types in CONUS Representative Counties Grouped by State



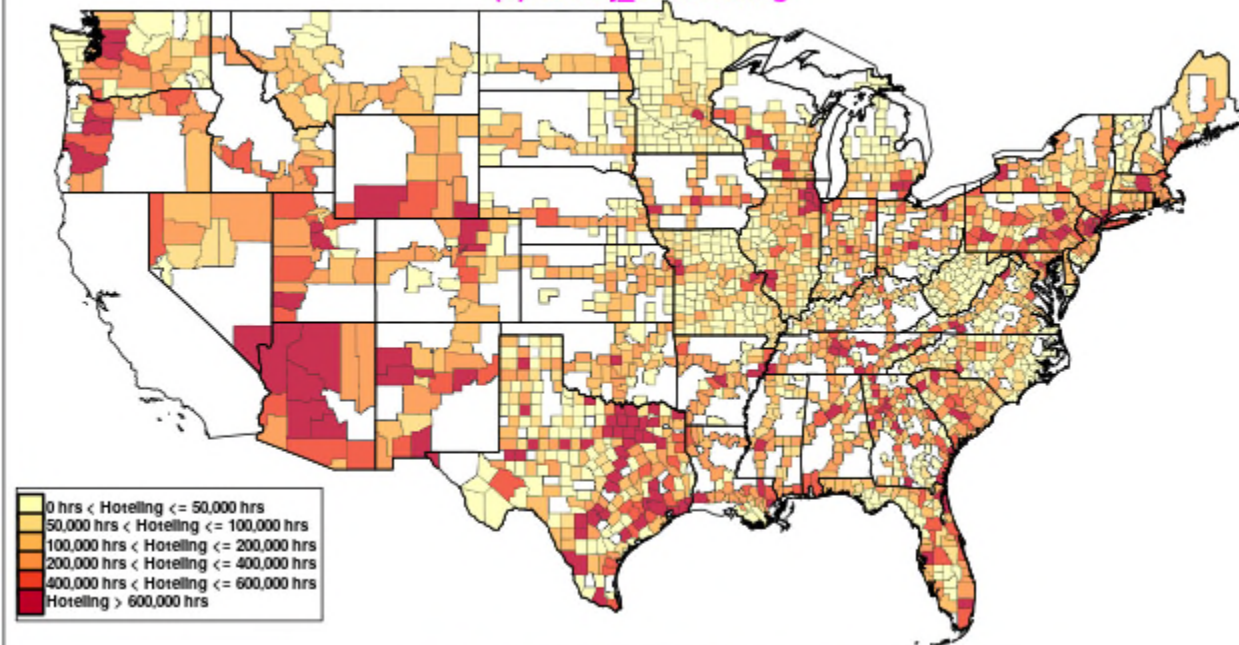




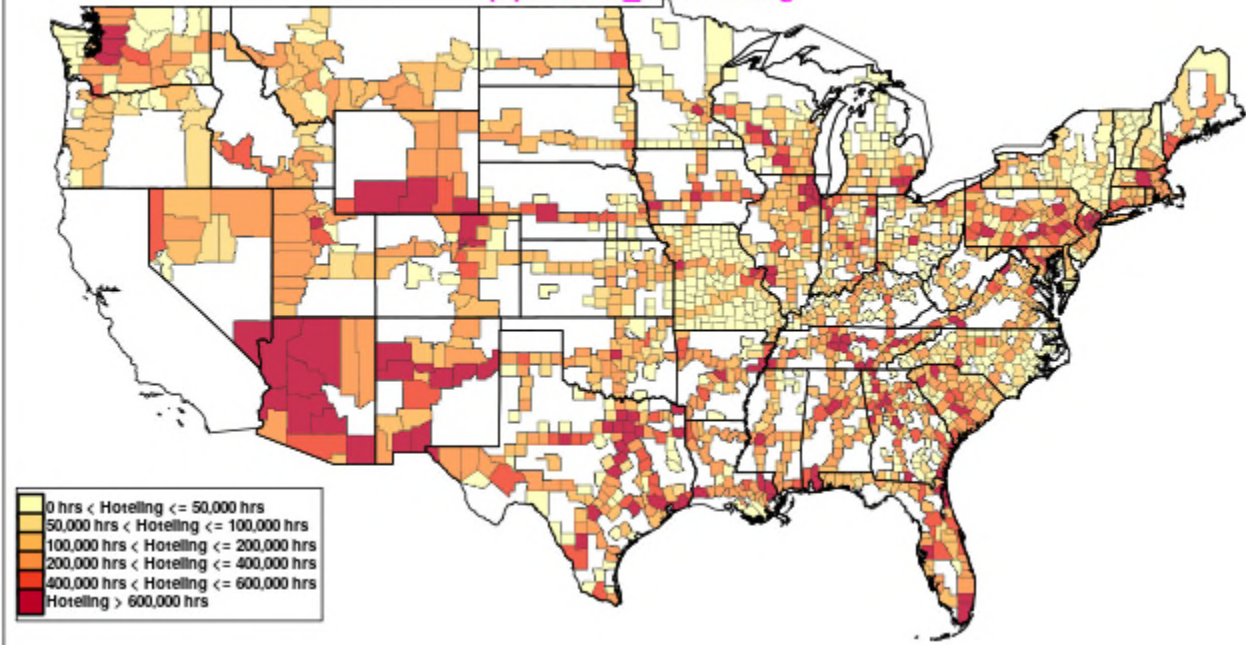
Same county-specific growth factors are applied to VMT, VPOP, STARTS, and ONI. Growth factors for HOTELING are slightly lower

State-supplied FY data by some states may be too low

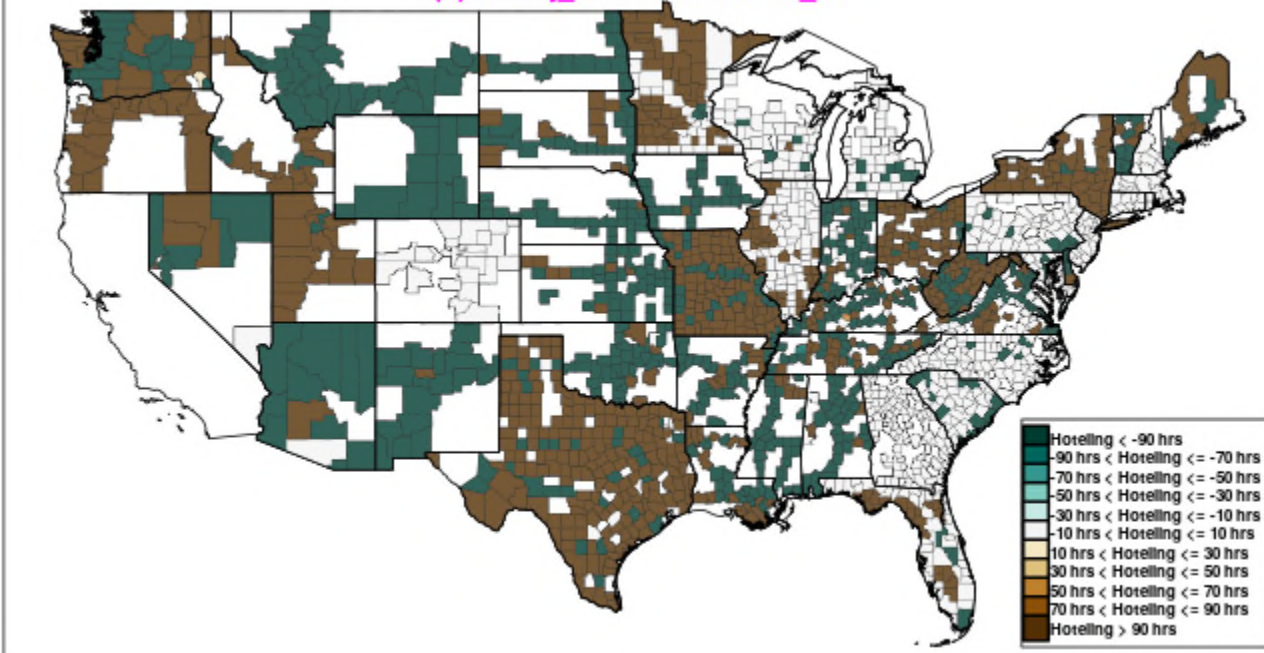
(a) 2016fj_v2 Hoteling



(b) 2016fh_v1 Hoteling



(c) 2016fj_v2 minus 2016fh_v1



HOTELING is implemented inconsistently among states. Some states have the activity in every single county (IL, IN, MO, SC, TX, WI)

Gasoline (1) Diesel (2) CNG (3) E85 (5) Electricity (9)

CA excluded

(a) 2016tj_v2 21 VPOP

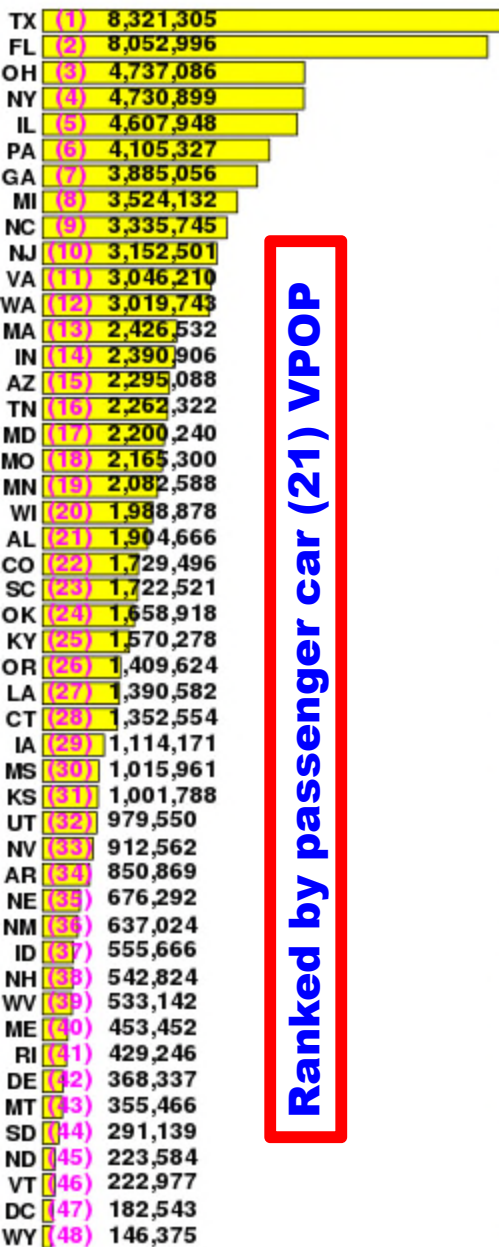
(b) 2016tj_v2 21 VMT

(c) 2016tj_v2 VPOP by Fuel (%)

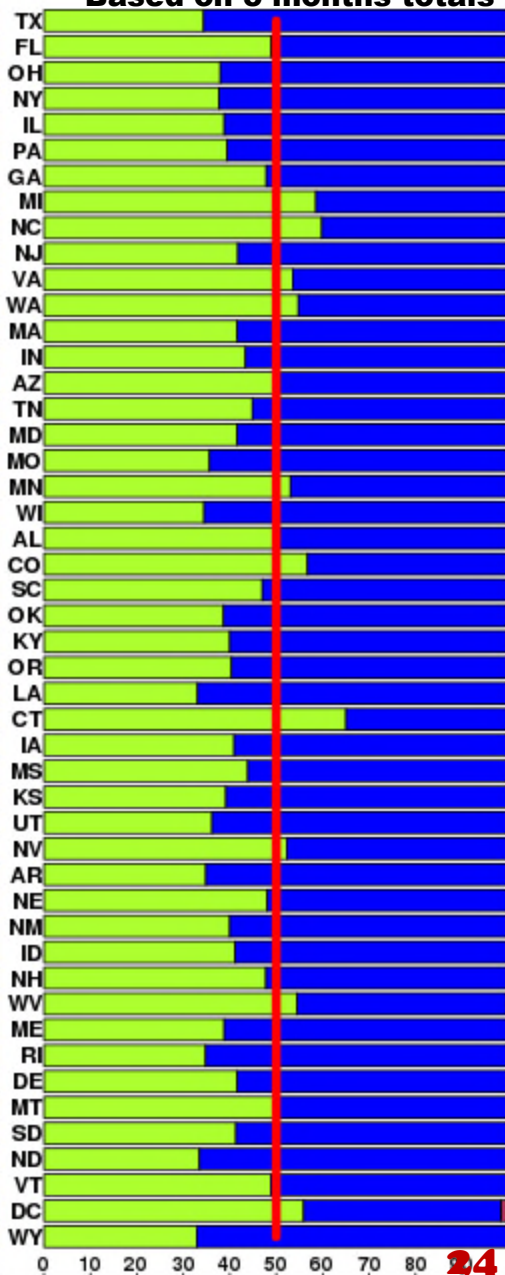
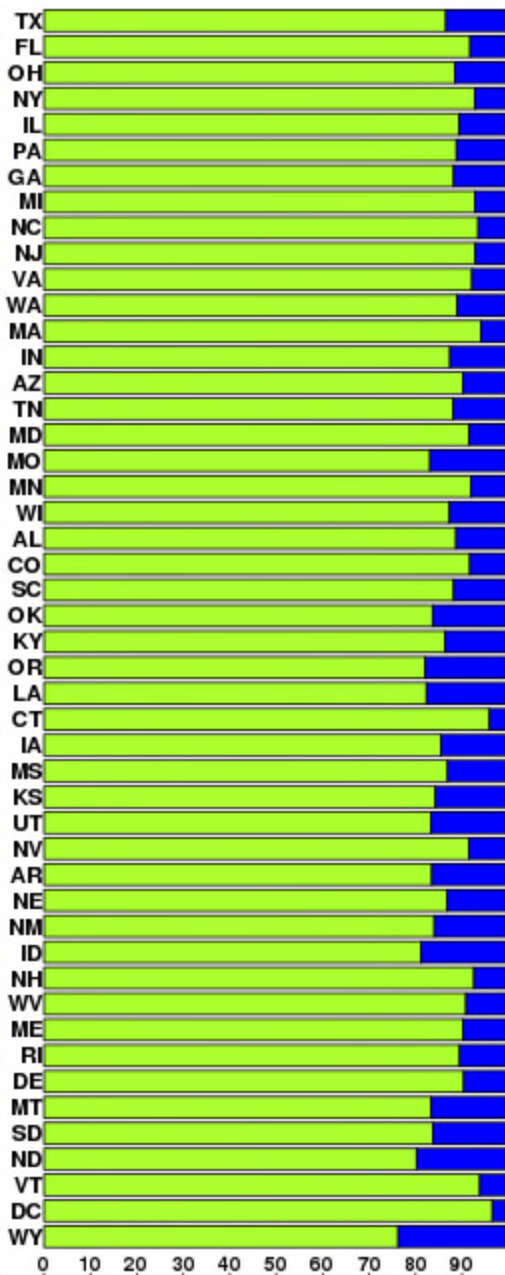
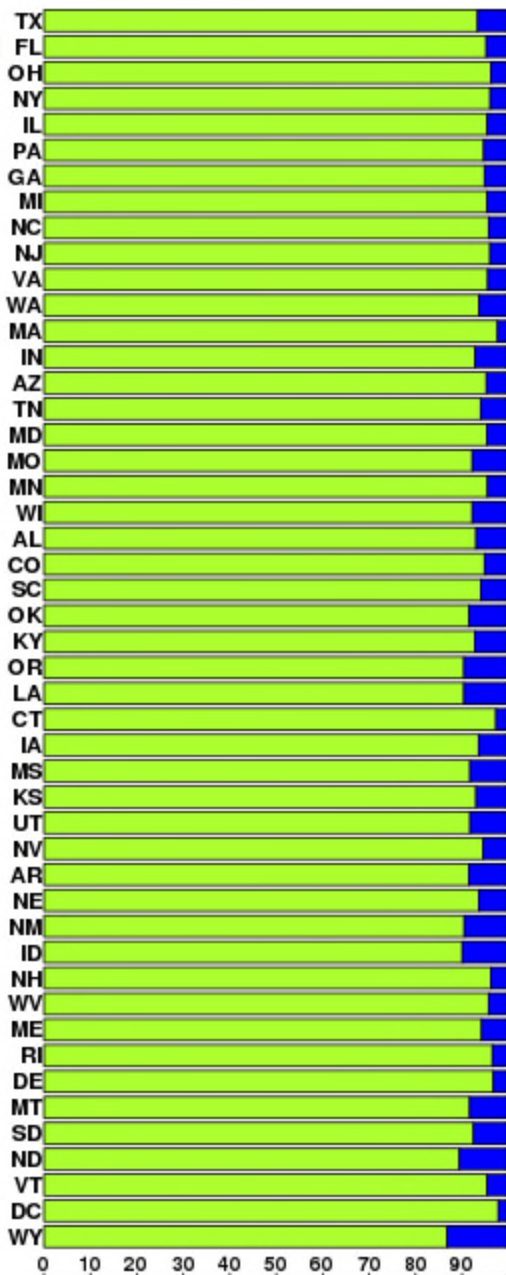
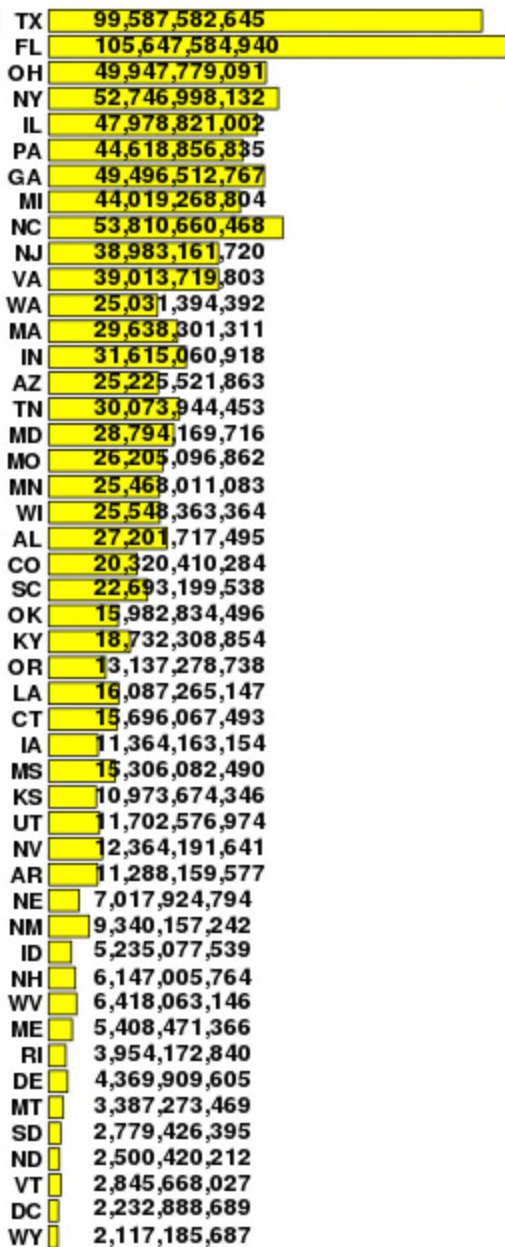
(d) 2016tj_v2 VMT by Fuel (%)

(e) 2016tj_v2 NOx by Fuel (%)

Based on 5 months totals

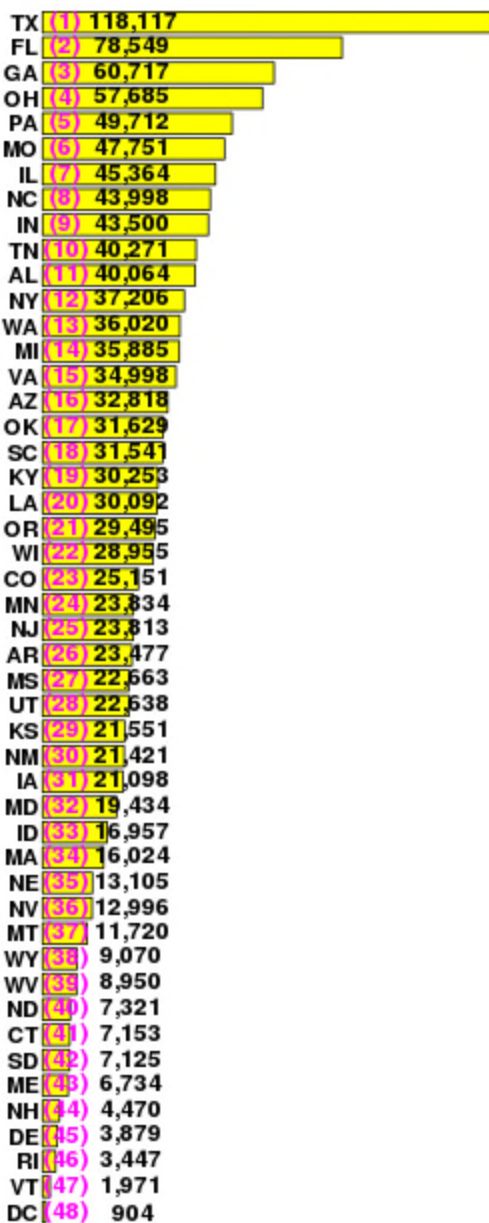


Ranked by passenger car (21) VPOP

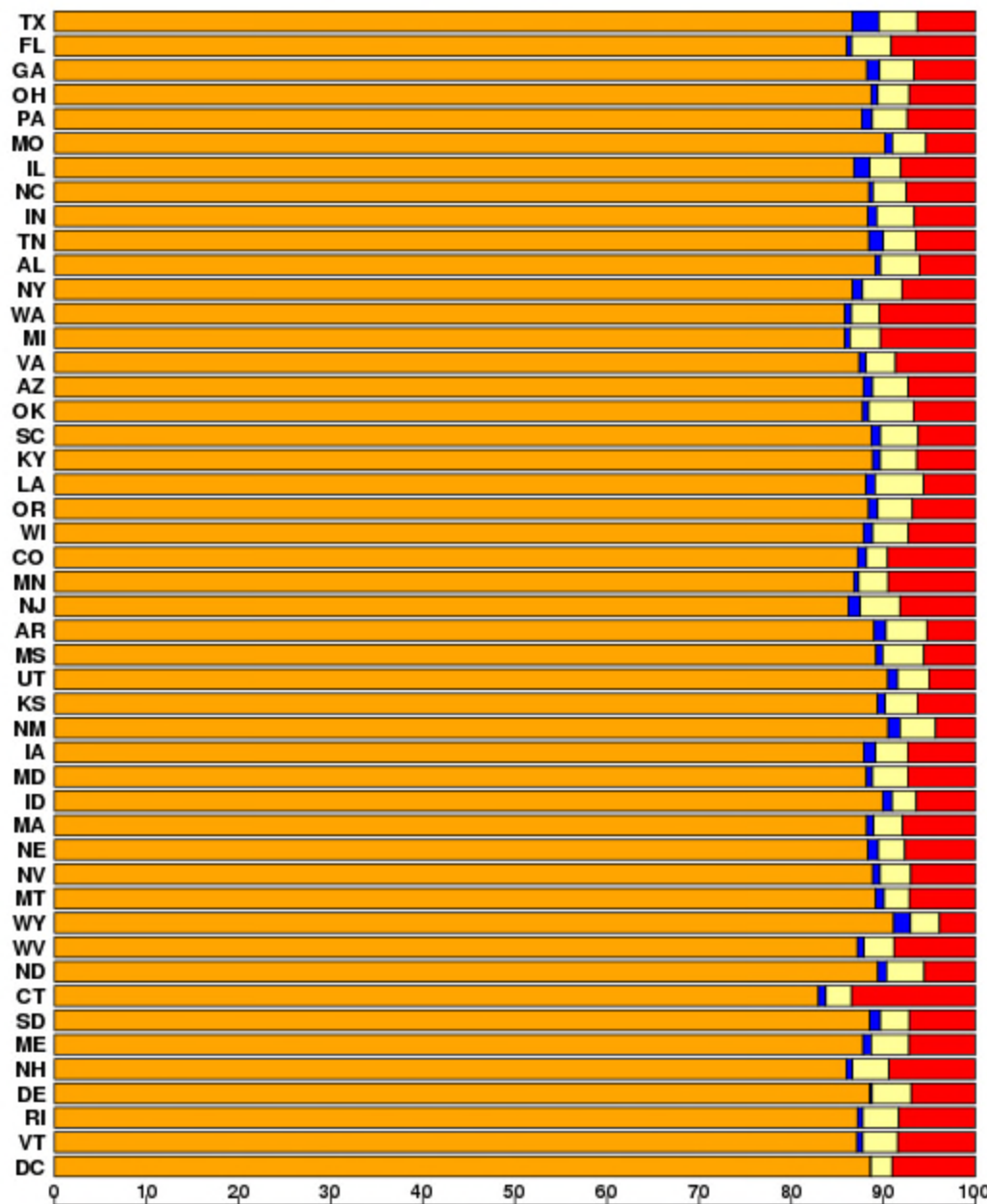


RPD RPH RPHO RPS RPV RPP

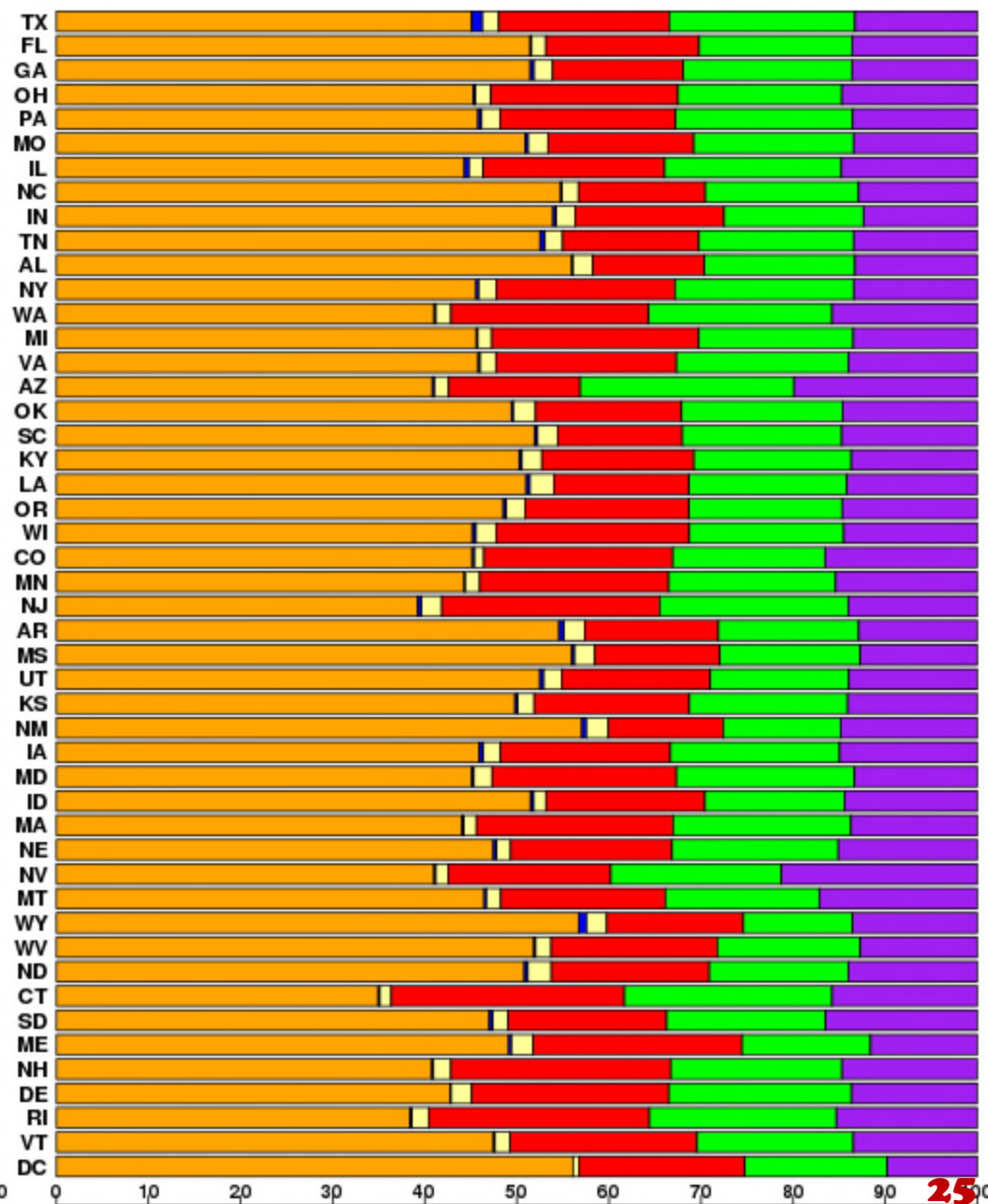
(a) 2016fj_v2 Five-Month NOx (tons)



(b) 2016fj_v2 NOx by Sector (%)

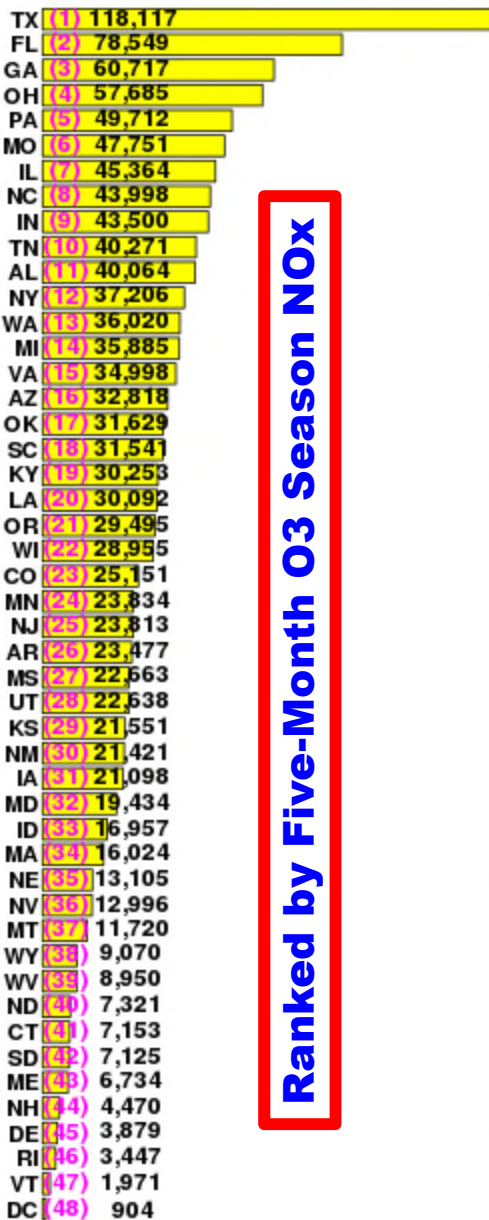


(c) 2016fj_v2 VOCs by Sector Type (%)



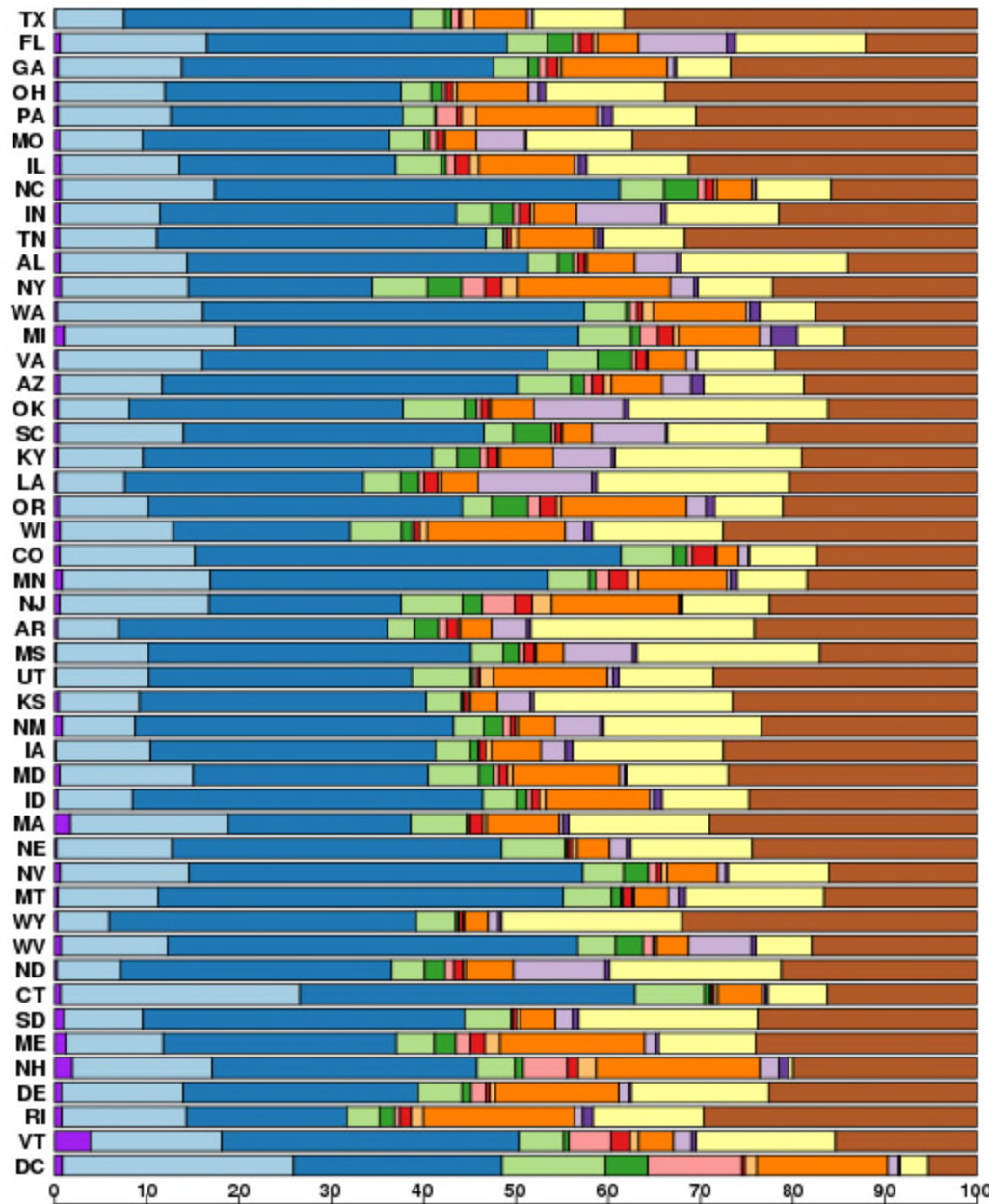


(a) 2016fj_v2 Five-Month NOx (tons)

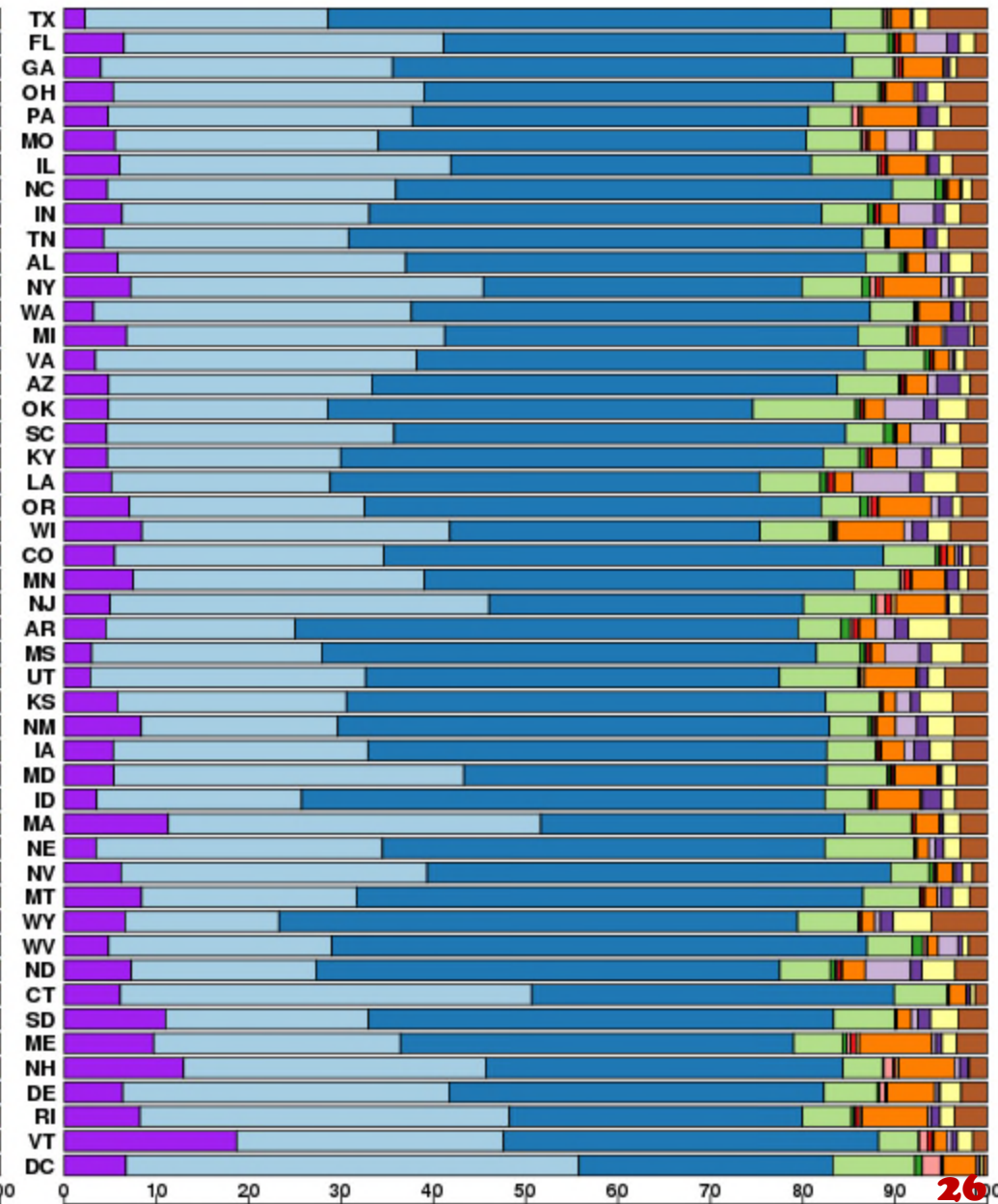


Ranked by Five-Month O3 Season NOx

(b) 2016fj_v2 NOx by Vehicle Type (%)

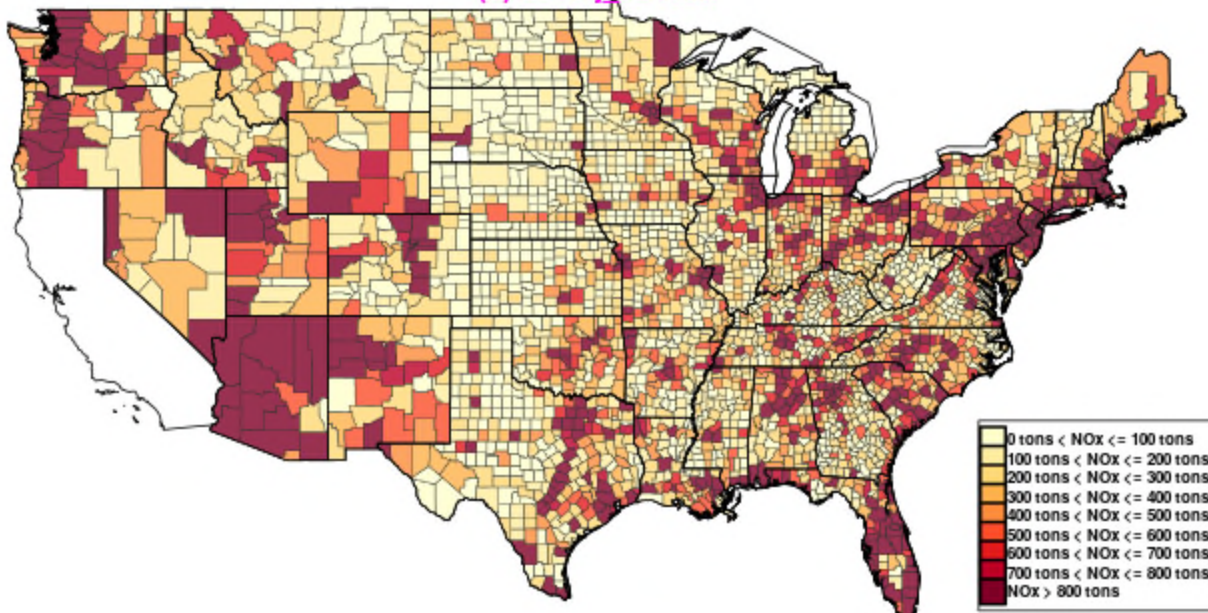


(c) 2016fj_v2 VOCs by Vehicle Type (%)

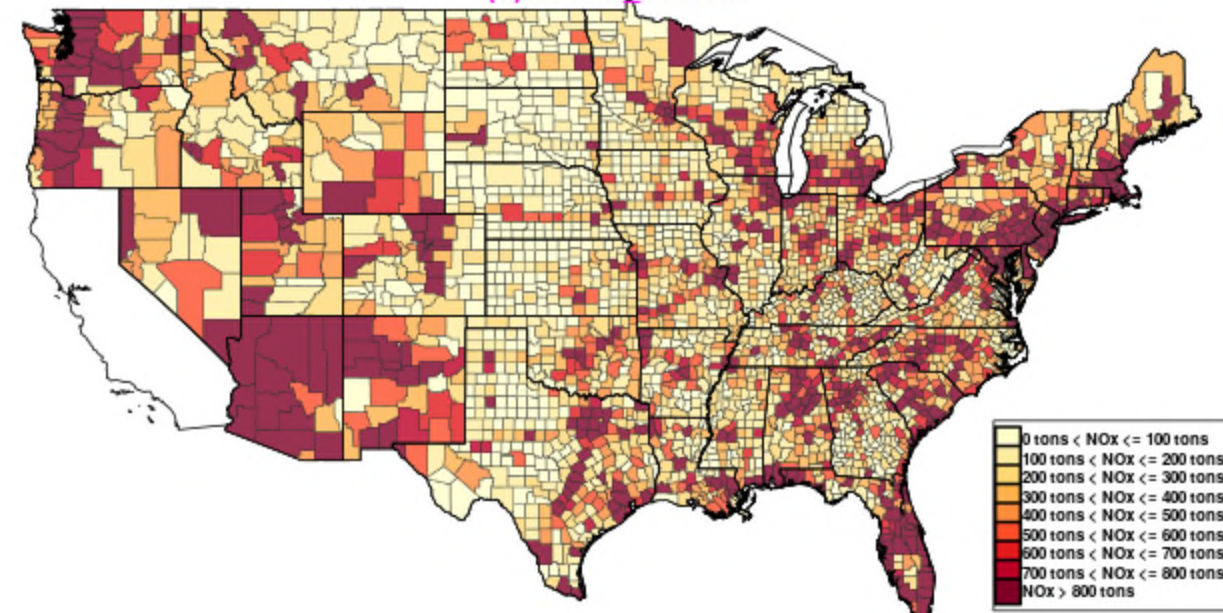


NOx Differences (in tons) over Five Months (May – September)

(a) 2016fj_v2 NOx

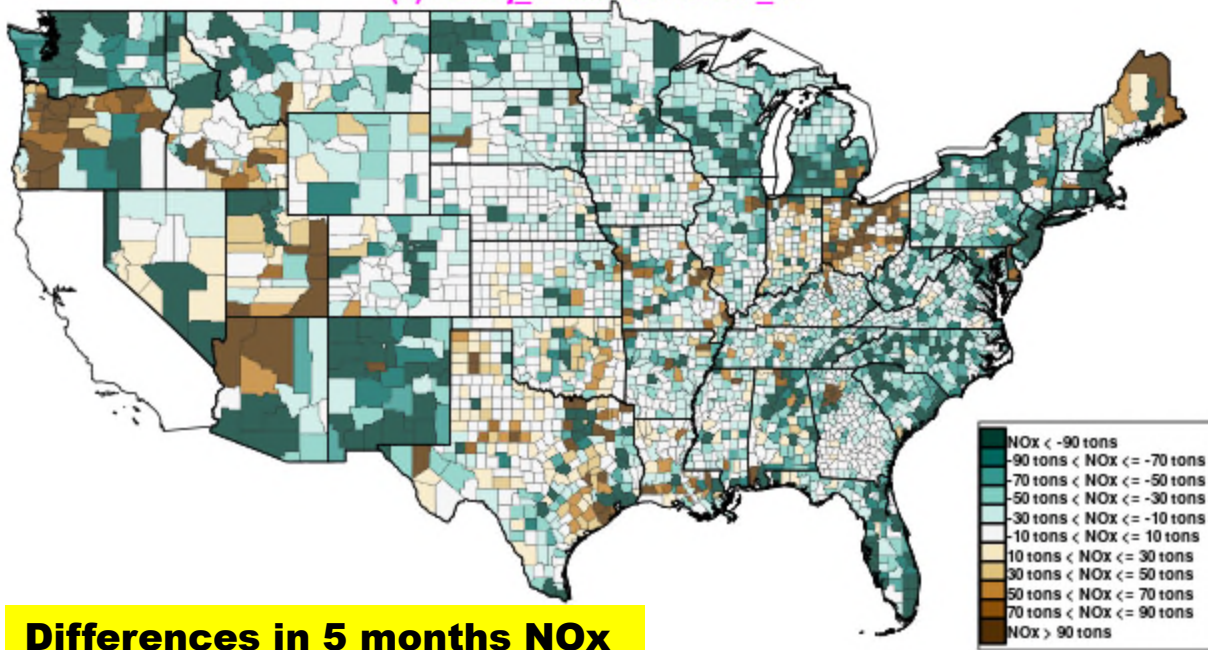


(b) 2016fh_v1 NOx



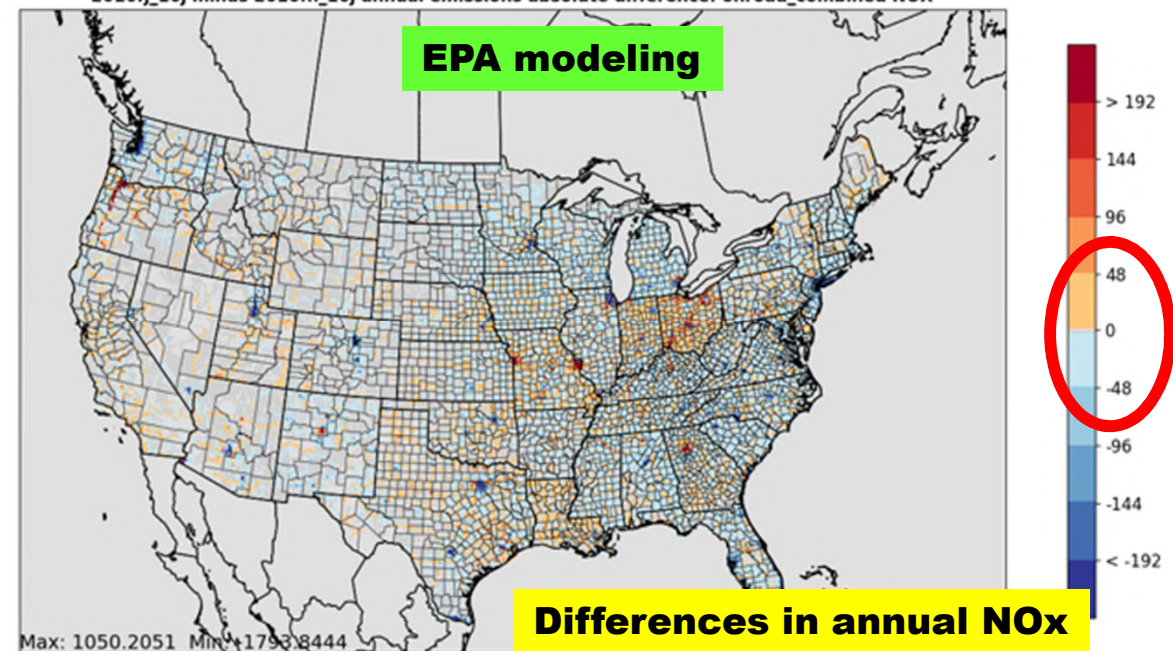
2016v2 < 2016v1. Version change, not future reduction!

(c) 2016fj_v2 minus 2016fh_v1



Differences in 5 months NOx

2016fj_16j minus 2016fh_16j annual emissions absolute difference: onroad_combined NOx

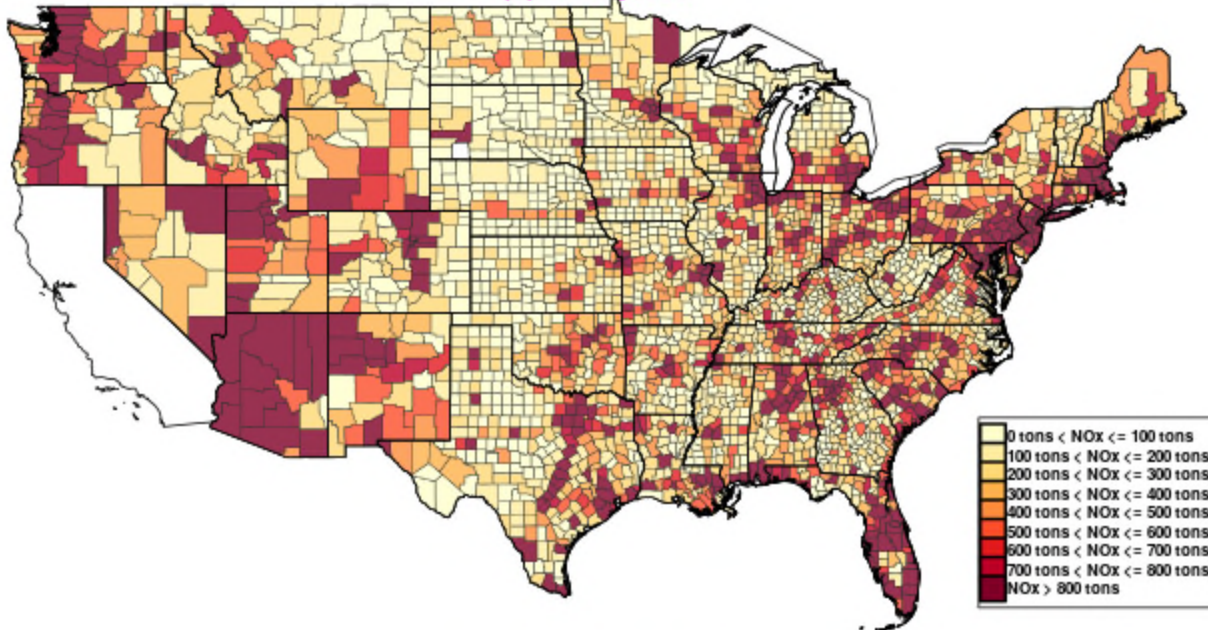


EPA modeling

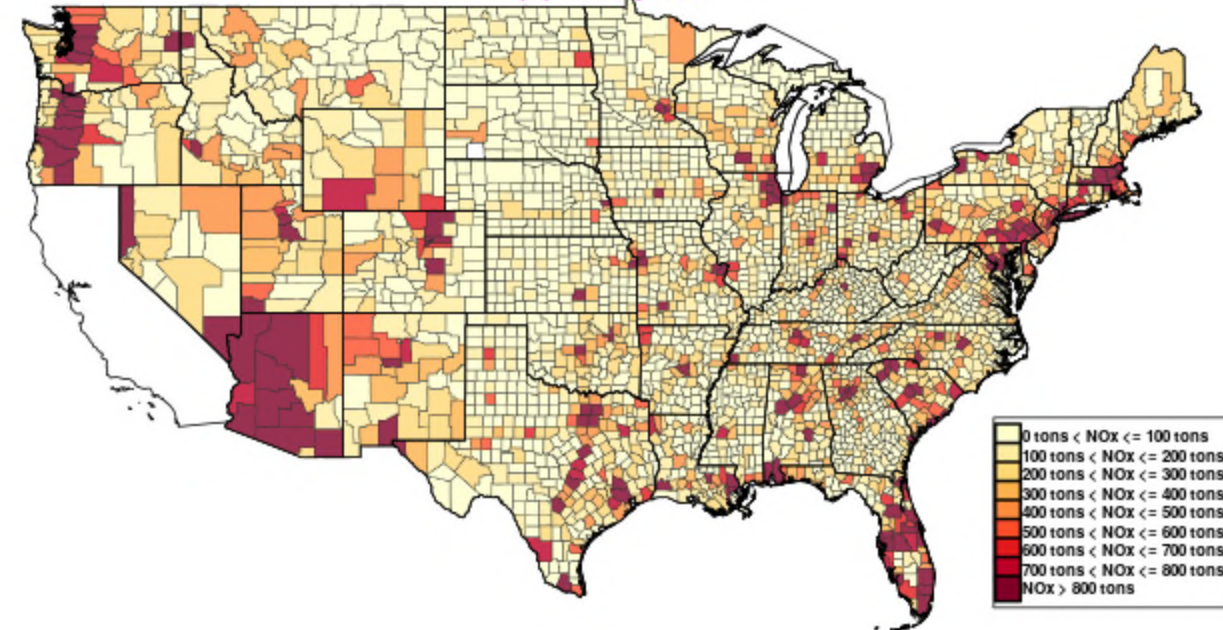
Differences in annual NOx

NOx Differences (in tons) over Five Months (May -- September)

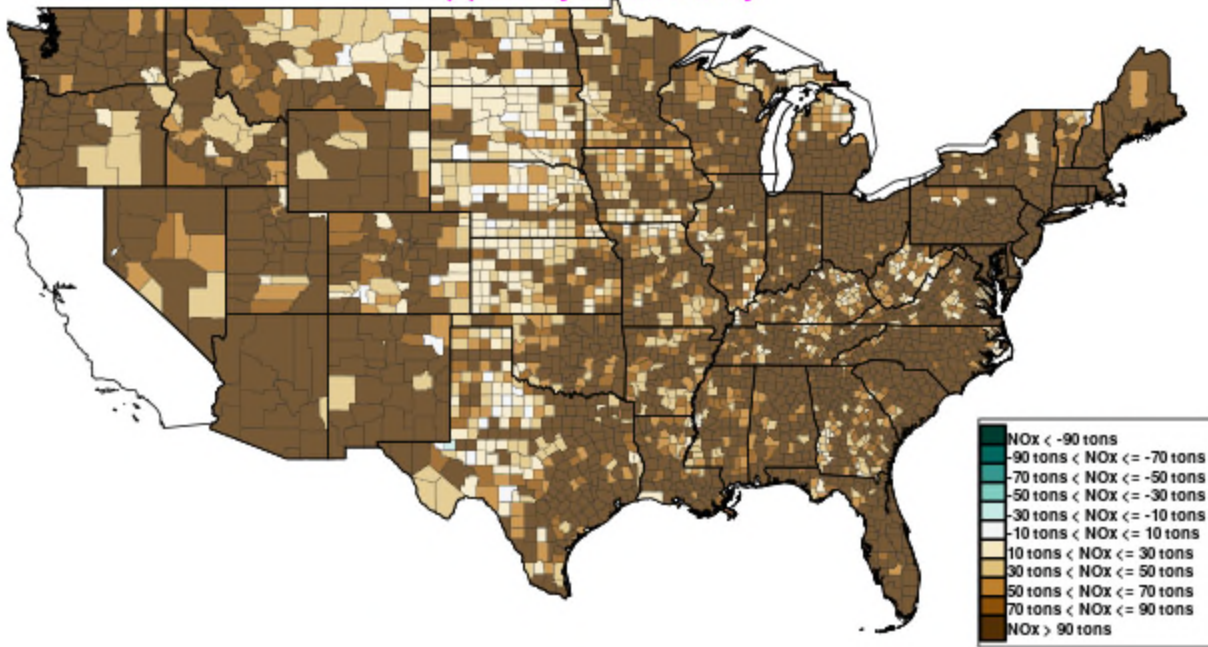
(a) 2016fj NOx



(b) 2023fj NOx



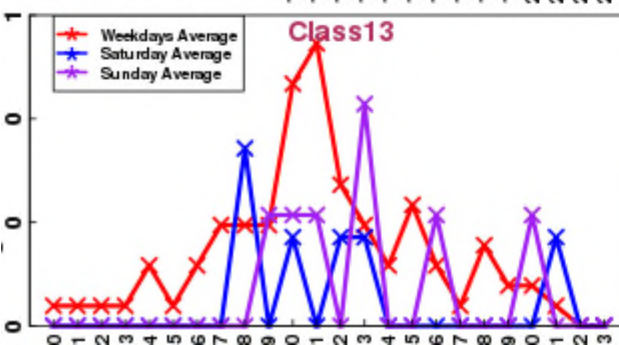
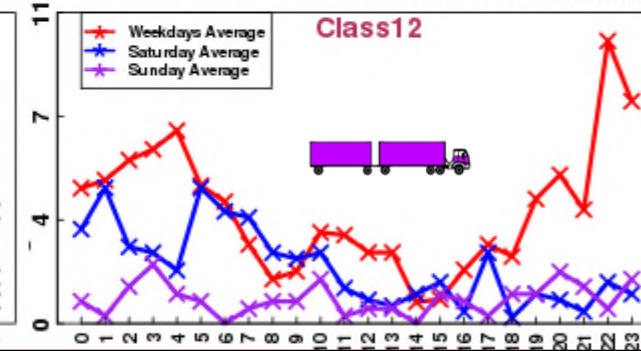
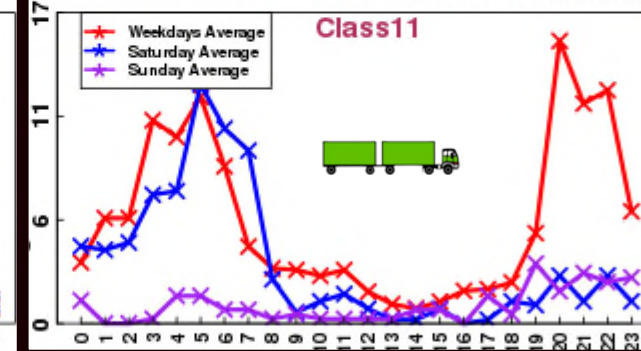
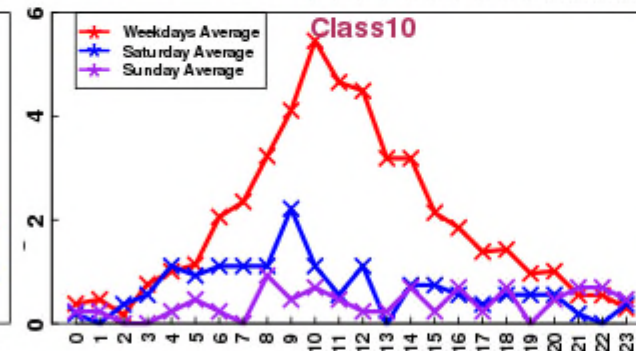
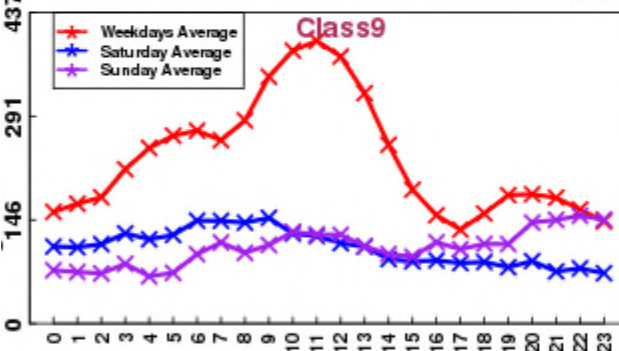
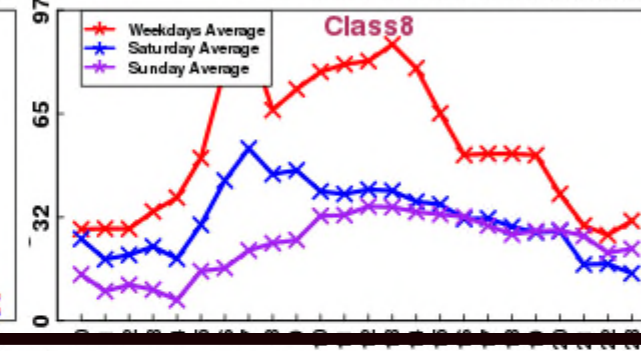
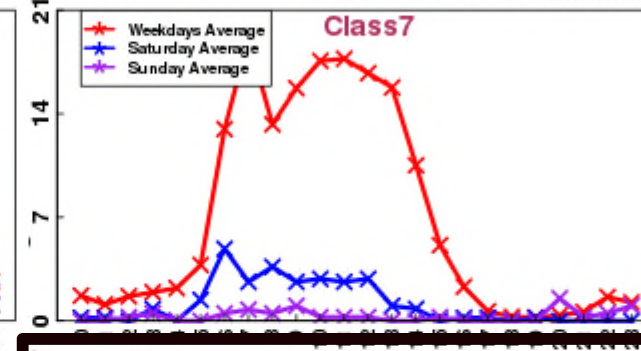
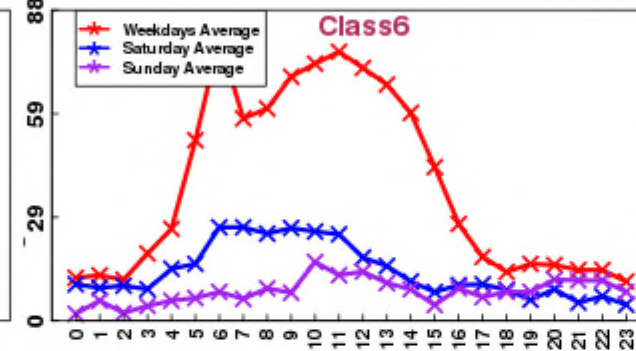
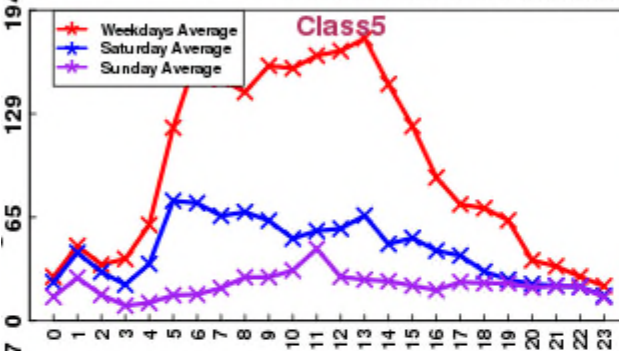
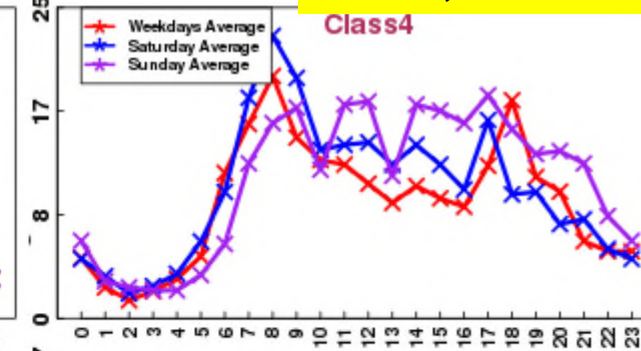
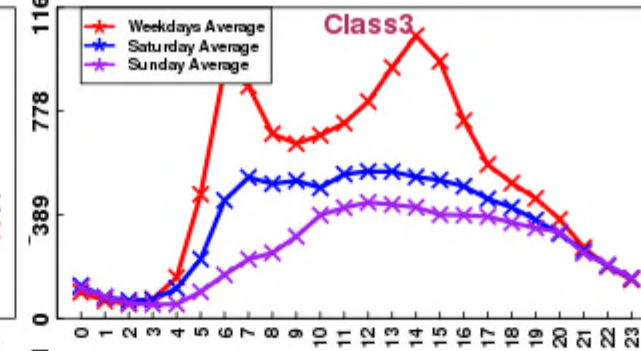
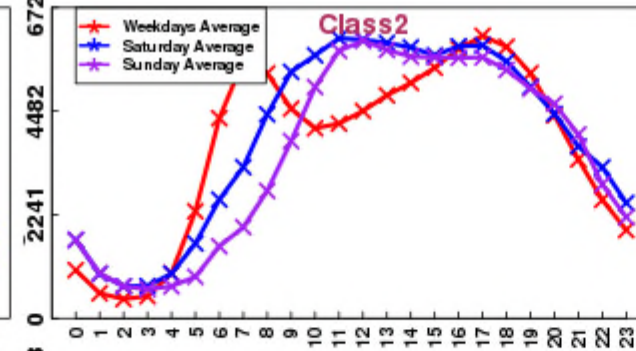
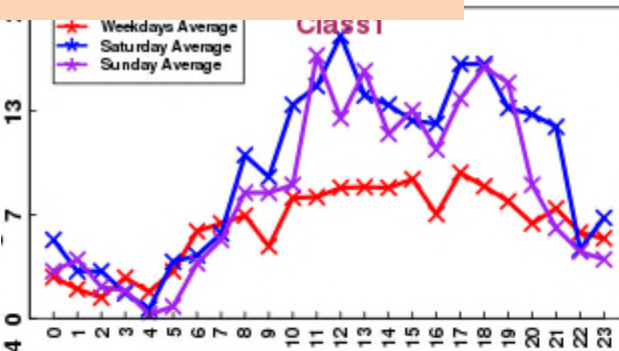
(c) 2016fj minus 2023fj



2016v2 > 2023

Future year 2023 NOx Reduction

FHWA Traffic Count



Both Class 11 and 12 peak in early morning and late night hours, similar to SMOKE extended idling profiles for tractor trailers or diesel combination long-haul trucks (62)

Average diurnal profiles were prepared in a way similar to average meteorology in MOVES

